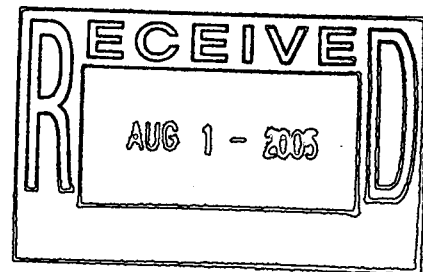


**ANNUAL REPORT
FOR THE
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE
GROUNDWATER PLUME TREATMENT SYSTEMS
January 2003 through December 2004**



August 1, 2005

ADMIN RECORD

1/75

SW-A-005120

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ACRONYMS AND ABBREVIATIONS

AL	Action Level
ALF	Action Level Framework
CAD/ROD	Corrective Action Decision/Record of Decision
CDPHE	Colorado Department of Public Health and Environment
CHWA	Colorado Hazardous Waste Act
COC	contaminants of concern
DNAPL	Dense Non-Aqueous Phase Liquid
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
g	grams
gpm	gallons per minute
GW	groundwater
HRC®	Hydrogen Release Compound®
ICP/MS	Inductively Coupled Plasma/Mass Spectrometer
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measure/Interim Remedial Action
IMP	Integrated Monitoring Plan
ITS	Interceptor Trench System
K-H	Kaiser-Hill Company, L.L.C.
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MIP	material insertion point
msl	mean sea level
ORP	oxidation-reduction potential
OU	Operable Unit
PAM	Proposed Action Memorandum
PCB	polychlorinated biphenyl
PCE	PCE
pCi/L	picocuries per liter
PL	Present Landfill
PMJM	Preble's meadow jumping mouse
POC	point of compliance
PU&D	Property Utilization and Disposal
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RMRS	Rocky Mountain Remediation Services
SAP	sampling and analysis plan
SPP	Solar Ponds Plume
TCE	TCE
uCi	microcuries
ug/kg	micrograms per kilogram
ug/L	micrograms per liter
UHSU	Upper Hydrostratigraphic Unit
VOC	volatile organic compound

1.0 INTRODUCTION

This report combines the calendar year 2003 and 2004 groundwater plume treatment systems annual reports. This report provides performance monitoring data and summarizes activities for the Mound Site Plume Treatment System, East Trenches Plume Treatment System, Solar Ponds Plume (SPP) Treatment System, Operable Unit (OU) 7 – Present Landfill Seep Treatment System, OU-1 Treatment System and Property Utilization and Disposal (PU&D) Yard Plume Treatability Study at the Rocky Flats Environmental Technology Site (RFETS). These systems were installed and the Treatability Study performed in accordance with approved Rocky Flats Cleanup Agreement (RFCA) (DOE 1996) decision documents. The three Plume Treatment systems are evaluated to determine whether the systems are operating properly and successfully. Based on the evaluation presented in this report, these three systems meet remedial objectives and are operating properly and successfully. These systems are summarized in Table 1.

Table 1. Groundwater Treatment Projects at RFETS

Project	Contaminant Type	Treatment Type
Mound Site Plume Treatment System	Volatile Organic Compounds (VOCs) Radionuclides	Collection trench with passive, zero-valent iron treatment cells
East Trenches Plume Treatment System	VOCs	Collection trench with passive, zero-valent iron treatment cells
Solar Ponds Plume Treatment System	Nitrates Uranium	Collection trench with solar-powered pump and passive treatment cells containing wood chips and zero-valent iron
OU 1 - 881 Hillside Groundwater Treatment System	VOCs Radionuclides	Treatment discontinued in 2002.
OU 7 - Present Landfill Passive Seep Interception and Treatment System	VOCs	Passive seep interception system with passive aeration treatment – Current system was upgraded and relocated in 2005.
PU&D Yard Plume Treatability Study	VOCs	Treatability study - <i>In situ</i> bioremediation using Hydrogen Release Compound (HRC) [®]

Operation of the OU 1 – 881 Hillside Groundwater Treatment System was discontinued in April 2002, in accordance with the Final Major Modification to the OU 1 CAD/ROD (DOE 2001). The 2003 sampling and analysis results are contained in the 2003 Annual Groundwater Monitoring Report (DOE 2004a).

At OU 7, a RFCA accelerated action to install a Resource Conservation and Recovery Act (RCRA)/Colorado Hazardous Waste Act (CHWA) compliant cover was implemented in accordance with the Interim Measure/Interim Remedial Action for the Present Landfill (PL IM/IRA) (DOE 2004b). The major components of the OU 7 Treatment System were upgraded and relocated based on the final configuration of the landfill cover. See the Accelerated Action for the Present Landfill Rocky Flats Environmental Technology Site Construction Certification Report (K-H 2005a).

The Mound Site Plume, East Trenches Plume, and Solar Ponds Plume systems are designed to passively intercept and treat contaminated groundwater in low-flow, low-permeability hydrogeologic regimes. These collection/treatment systems are low-maintenance/low-profile systems that are designed for long-term treatment. The PU&D Treatability Study evaluates an *in situ* process to treat contaminants within the plume source area rather than capturing a plume front.

The contaminated groundwater plumes, in which the three passive collection and treatment systems and the treatability study were deployed, are evaluated in a Interim Measure/Interim Remedial Action for Groundwater at the Rocky Flats Environmental Technology Site (Groundwater IM/IRA) (DOE 2005a). The Groundwater IM/IRA is subject to public review and comment, and approval by the Colorado Department of Public Health and Environment (CDPHE) and the Environmental Protection Agency (EPA), Region VIII after consideration of comments and incorporation of any required changes. The Groundwater IM/IRA addresses groundwater contamination areas on the site.

2.0 MOUND SITE PLUME TREATMENT SYSTEM

The Mound Site Plume Treatment System was installed in 1998 pursuant to the Final Mound Site Plume Decision Document: A Major Modification to the Final Surface Water Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document for South Walnut Creek (Mound Site Plume Decision Document) (DOE 1997a). System installation is documented in the Final Mound Site Completion Report (DOE 1999a).

The Mound Site Plume Treatment System collects and treats contaminated groundwater from the Mound Site and Oil Burn Pit #2 area. Contaminated soil was removed from the Mound Site in 1997 in accordance with the Final Proposed Action Memorandum for the Source Removal at the Mound Site, IHSS 113 (DOE 1997b). Installation of the 220-foot-long collection system and two treatment cells containing reactive iron was completed in 1998 (Figure 1). Treated water is discharged back into the groundwater on the downgradient side of the treatment cells through a discharge gallery designed to overflow to the surface when the surrounding soils are saturated. Overflow discharges to the surface immediately downgradient of the treatment cell near South Walnut Creek.

In early 2005, 15,000 cubic yards of polychlorinated biphenyl (PCB) and VOC-contaminated soil was removed from the Oil Burn Pit #2 in accordance with Environmental Restoration (ER) RFCA Standard Operating Procedure (RSOP) (Individual Hazardous Substance Site Group 900-2) (DOE 2005b). To initiate *in-situ* enhanced biodegradation, HRC-X™, an amendment, was placed into the bottom of the excavation. HRC-X™ is an extended release amendment similar to HRC® described in Section 7.0. A gravel layer was added to allow for better mixing of the amendment with groundwater so that residual soil contamination is more accessible for biodegradation. The remaining excavation was then backfilled with soil with additional amendment added into the excavation at depths where residual contaminated soils were present. Application of the amendment is a one-time event and is intended to reduce the source of groundwater contamination. This amendment is anticipated to boost the production of resident microbes that will effectively reduce the amount of residual VOC contamination remaining at this project site.

Figure 1
Mound Plume Treatment
System Locations

Rocky Flats Environmental Technology Site

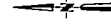
EXPLANATION

- ⊕ New Ground Water Well
- ⊕ Existing Ground Water Well
- New Trench Water-Level Monitoring Probes
- ⊙ New Trench Cleanout
- Contours
- Fences
- 72" Culvert
- Trench System

Standard Map Features

- Buildings and other structures
- ▨ Demolished buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- == Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
Source for all Detailed Key Lines except the new groundwater wells is International Technology Corporation, Inc. in Boulder, Montana.
Buildings, fences, hydrography, roads and other features are from the 1995 aerial photograph data captured by EG&G RSI, Las Vegas. Digitized from the orthorectified photos 1/95.



Scale = 1 : 1170
1 inch represents approximately 68 feet

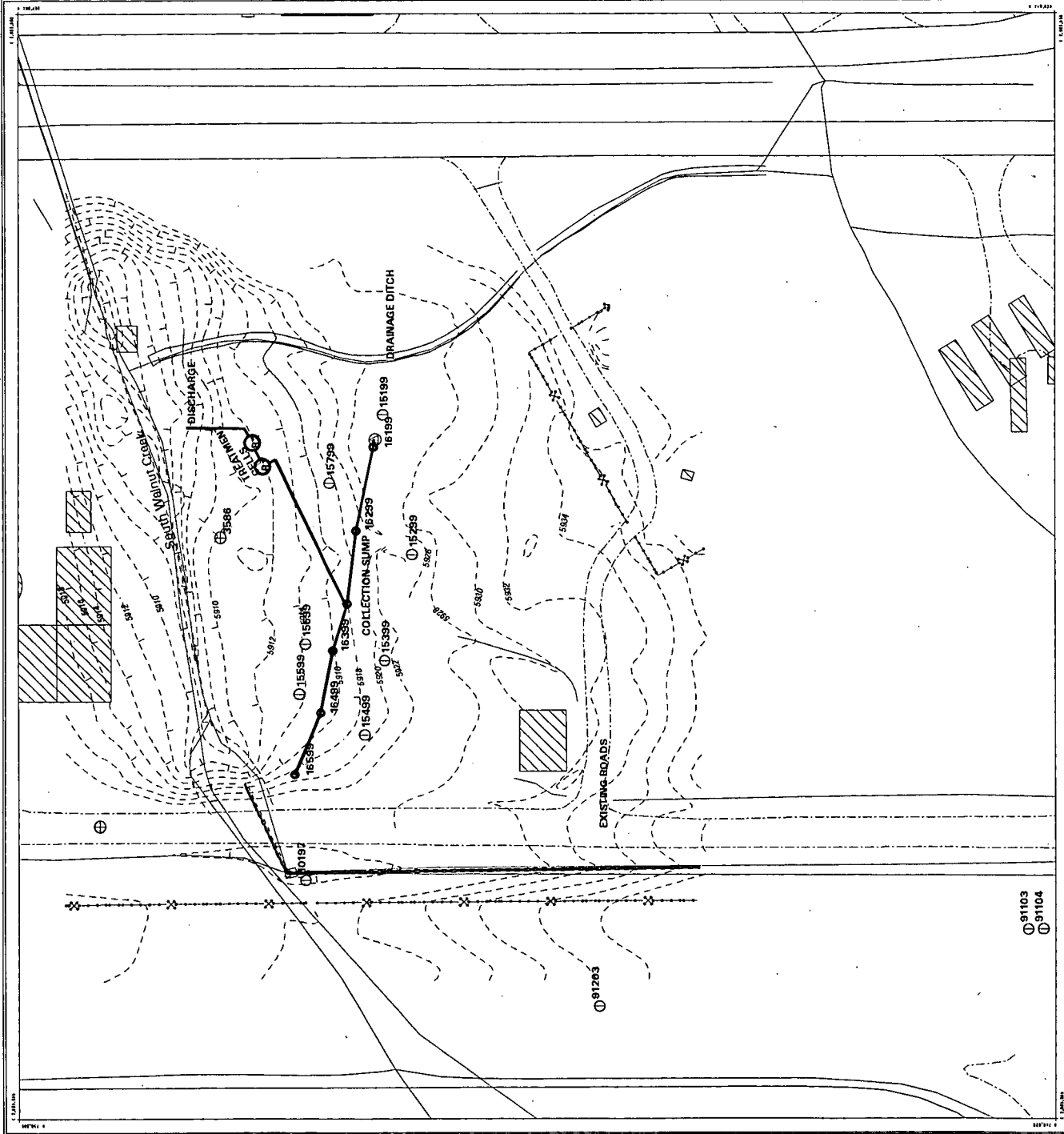
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD 83

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by: CH2M HILL



June 06, 2005



The excavation for the Oil Burn Pit #2 extends to the storm drain line. The storm drain acts as a preferential pathway for the groundwater in this area. In March 2005, following soil excavation of the Oil Burn Pit #2, a trench was excavated and filled with gravel to direct the flow from the base of the storm drain to the Mound Site Plume collection trench to augment the capture of this flow. Although modeling results already indicated that the existing system was capturing the plume, including flow from Oil Burn Pit # 2, the addition of this trench should further ensure the capture of groundwater on the west side of the Mound Site Plume. The combination of soil removal, enhanced collection trench recovery, and *in-situ* enhanced biodegradation should have an overall beneficial effect on the Mound Plume, and could reduce the amount of time that the groundwater treatment system is needed. Additional details are provided in the Groundwater IM/IRA (DOE 2005a) and the closeout report (DOE 2005c).

2.1 Decision Document Objectives

As stated in the Mound Site Plume Decision Document (DOE 1997a), the objectives for this project were to:

1. Intercept and treat contaminated groundwater, including seep SW059, at the distal end of the Mound Site Plume.
2. Design and install a passive groundwater treatment system that, to the extent practicable, protects surface water and reduces the contaminant mass loading in surface water consistent with the RFCA Action Level Framework (ALF).
3. Design the reactive metals treatment system and the barrier wall construction method to minimize the generation of low-level mixed waste and/or low-level waste.
4. Design the reactive metals treatment system for easy access for operation and maintenance, and for ease in media replacement or final removal.
5. Develop cost and performance data for design of low cost and effective treatment systems.
6. Minimize the impacts to the Preble's meadow jumping mouse (PMJM) during construction by installing silt fences between the construction area and the creek to prevent downstream sedimentation of habitat.
7. Avoid depletion of waters to South Walnut Creek.

This report describes how objectives 1 and 2 are met. It also provides information related to Objective 5. The other objectives were met during design and construction and are not specifically evaluated in this report.

2.2 Treatment Performance, Monitoring and Maintenance

System performance monitoring locations and frequency required by the Mound Site Plume Decision Document (DOE 1997a) are shown in Table 2.

2.2.1 Treatment Performance

Installation of this system eliminated the discharge at Seep SW059. Groundwater that previously discharged at the seep is now collected and treated by the Mound Site Plume Treatment System.

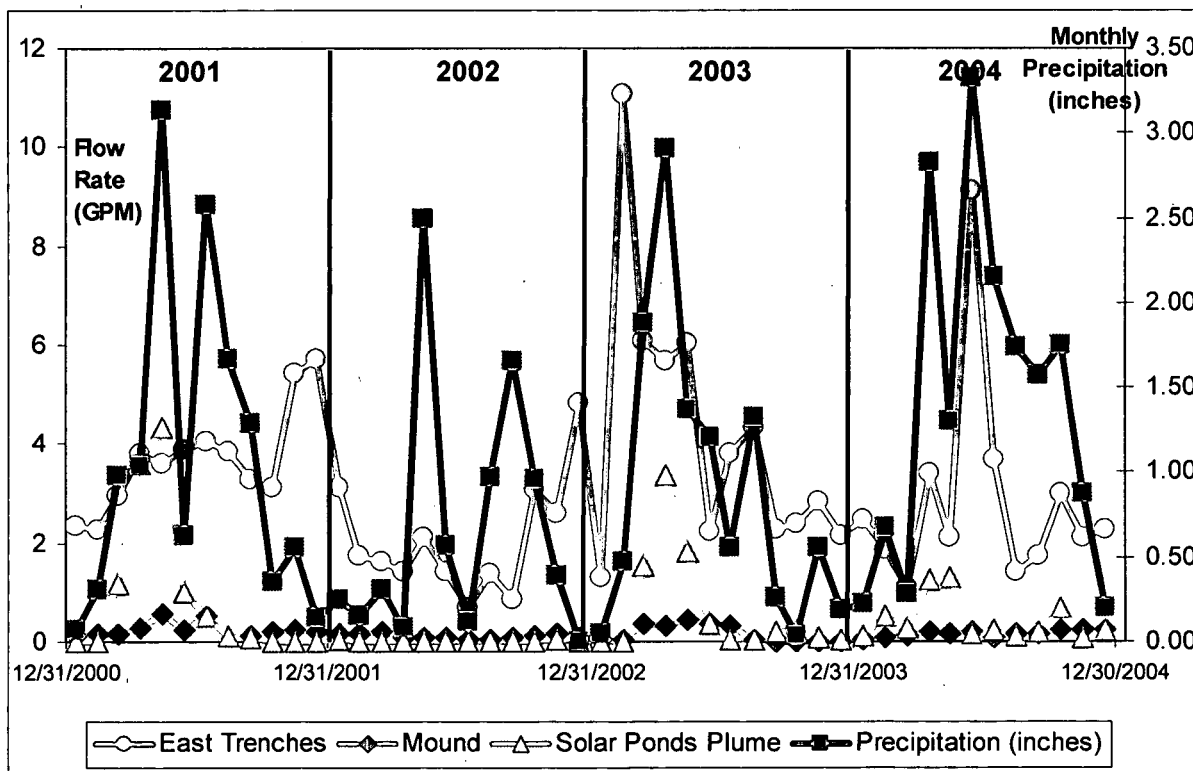
For the period January 1, 2003 through December 31, 2003, 82,000 gallons of contaminated water were treated. For the same period in 2004, 86,000 gallons of groundwater were treated. The total volume of groundwater treated as of December 31, 2004 was approximately 1,001,000 gallons. Measured flow rates in 2003 ranged from no measurable flow for most dates starting from the end of August through mid-December to a high flow rate of 3.67 gallons per minute (gpm) on March 26. In 2004, flow rates ranged from 0.021 to 1.065 gpm. The average daily flow rate in 2003 was 0.17 gpm, and in 2004 was 0.164 gpm. Monthly flow rates are shown on Figure 2.

Table 2. Monitoring Requirements for the Mound Site Plume Treatment System

Task	Month 1	Months 2-6	Months 7-12	Subsequent Years
Treatment System Influent (R1I)	Monthly	Monthly	Monthly	Not required
Treatment System Effluent (R2E)	Weekly	Monthly	Quarterly	Semi-Annually
Downgradient Water Quality – Well 3586	Quarterly	Quarterly	Quarterly	Semi-Annually
Hydraulic Head-water level measurements	Weekly	Monthly	Quarterly	Semi-Annually

Note: Water levels were also collected for each sampling event. While influent samples were not required after 12 months, influent samples were collected at the same time as effluent samples in 2003 and 2004.

Figure 2. Monthly Precipitation vs. Average Monthly Flow Rates for Mound Site Plume, East Trenches Plume and SPP Treatment Systems



The treatment system effectiveness is determined by comparison of the influent and effluent contaminant concentrations. As shown in Tables 3 and 4, the treatment system is effectively removing VOCs and radionuclides and the effluent meets surface water standards. The principal organic contaminants entering the treatment system are tetrachloroethene (PCE), trichloroethene (TCE), carbon tetrachloride, and their degradation products. A number of additional compounds are found in trace concentrations including carbon disulfide and benzene. Uranium isotopes are present in the influent but are removed to below detection limits in the effluent. Sampling for total uranium concentration instead of uranium isotopes was initiated in 2004 to make sampling consistent with the Integrated Monitoring Plan (IMP). Samples are no longer analyzed for americium-241 or plutonium-239/240 because of the very few detects and low activities seen when detected.

Table 3. Summary of Mound Site Plume 2003 Sampling Events

Contaminant	Influent Concentrations	Effluent Concentrations	RFCA Tier II Groundwater AL	RFCA Surface Water AL	Unit
Benzene	ND	ND-0.25	5	1.2 (5) [†]	ug/L
Carbon Tetrachloride	73-104D	ND	5	0.25 (5) [†]	ug/L
Carbon Disulfide	ND-0.44J	ND	3,650	3.65	ug/L
Cis-1,2-dichloroethene	9-23	1-4.4	70	70	ug/L
Chloroform	19-21.4	ND-0.93J	100	5.7	ug/L
1,1-Dichloroethane	ND-1	ND-1	3,650	3.65	ug/L
1,2-Dichloroethane	ND-0.39J	ND-0.31J	5	0.4 (5) [†]	ug/L
1,1-Dichloroethene	0.39J-2	ND-0.23J	7	0.057 (7) [†]	ug/L
Methylene Chloride	ND	3.5B	5	4.7	ug/L
PCE	22.6-31	ND-0.38J	5	0.8 (5) [†]	ug/L
1,1,1-Trichloroethane	2-2.8	ND	200	200	ug/L
TCE	31.4-38	ND-0.31J	5	2.7 (5) [†]	ug/L
Vinyl Chloride	ND-0.81J	ND	2	2	ug/L
Americium-241	ND	ND	0.145	0.15	pCi/L
Plutonium-239/240	ND	ND	0.151	0.15	pCi/L
Uranium-233, 234	3.16-6.16	ND	1.06	10	pCi/L
Uranium-235	ND-0.371J	ND	1.01	10	pCi/L
Uranium-238	2.27-3.84	ND	0.768	10	pCi/L

AL = Action Level

B = detected in laboratory blank

D = diluted

J = detected at concentrations below the required detection limit

ND = not detected at the detection limit for this analysis

ug/L = micrograms per liter

pCi/L = picocuries per liter

[†] = Parenthetical values are temporary modifications in effect through 2009.

Table 4. Summary of Mound Site Plume 2004 Sampling Events

Contaminant	Influent Concentrations	Effluent Concentrations	RFCA Tier II Groundwater AL	RFCA Surface Water AL	Unit
Carbon Tetrachloride	91.9-100	ND	5	0.25 (5) [†]	ug/L
Cis-1,2-dichloroethene	5.59-6.98	ND-0.33 J	70	70	ug/L
Chloroform	22.4-24.6	ND	100	5.7	ug/L
1,1-Dichloroethene	1.49-2.47	ND	7	0.057 (7) [†]	ug/L
PCE	21.5-25.7	ND-0.72 J	5	0.8 (5) [†]	ug/L
1,1,1-Trichloroethane	1.34-2.07	ND	200	200	ug/L
TCE	28.3-29.4	ND-2.74 J	5	2.7 (5) [†]	ug/L
Uranium-233/234	3.95	ND	1.06	10	pCi/L
Uranium-235	ND	ND	1.01	10	pCi/L
Uranium-238	2.97	ND	0.768	10	pCi/L
Total Uranium	9.03	0.261 J	-	-	ug/L

J = detected at concentrations below the required detection limit

ND = not detected at the detection limit for this analysis

ug/L = micrograms per liter

pCi/L = picocuries per liter

[†] = Parenthetical values are the temporary modifications in effect through 2009

The approximate contaminant mass removed is shown in Table 5 and was calculated based on the total measured flow and the midpoint of the contaminant concentration range from Tables 3 and 4. Mass removed is reported as grams (g) or microcuries (uCi). Previous years are included for comparison. Volumes in 1999/2000 represent two years of water treatment and are approximate volumes because of problems with the flow meter. However, these values represent the appropriate order of magnitude volumes. Volumes are higher because of higher precipitation during this time frame.

2.2.2 Groundwater Monitoring

Well locations are shown on Figure 1. Downgradient water quality is monitored at Well 3586 to determine the ability of the groundwater collection system to limit plume expansion and to mitigate potential increases in plume contaminant concentrations at this location. Well 3586 is the Mound Site Plume Decision Document designated performance monitoring well. Sampling results for other downgradient groundwater wells in this area also provide information on the barrier performance and are reported in Section 2.2.2.2. The groundwater quality monitoring results for certain wells upgradient of the barrier are also included to allow comparison with treatment cell influent concentrations, and to monitor for possible changes in groundwater flows and contaminant concentrations because of the barrier. The sampling regime for these other groundwater monitoring wells is specified in the IMP for 2003 (DOE 2003).

Table 5. Approximate Contaminant Mass Removed at Mound Site Plume System

Year	Contaminant	Influent (ug/l)	Effluent (ug/l)	Removed conc. (ug/l)	Volume Treated (liters)	Total Mass Removed (g or uCi)
2004	Carbon Tetrachloride	95.95	ND	95.95	325,500	31.2
	Tetrachloroethene	23.6	0.36	23.24	325,500	7.6
	Trichloroethene	28.85	1.37	27.48	325,500	8.9
	Total Uranium* pCi/l	6.87	0.107	6.76	325,500	2.2
2003	Carbon Tetrachloride	88.5	ND	88.5	310,400	27.5
	Tetrachloroethene	26.8	0.19	26.6	310,400	8.3
	Trichloroethene	34.7	0.16	34.5	310,400	10.7
	Total Uranium* pCi/l	8.0	ND	8.0	310,400	2.5
2002	Carbon Tetrachloride	120.0	ND	120.0	200,600	24.1
	Tetrachloroethene	37.3	ND	37.3	200,600	7.5
	Trichloroethene	61.4	ND	61.4	200,600	12.3
	Total Uranium** pCi/l	7.21	ND	7.2	200,600	1.4
2001	Carbon Tetrachloride	101.5	ND	101.5	450,000	45.7
	Tetrachloroethene	47.0	ND	47.0	450,000	21.2
	Trichloroethene	75.0	ND	75.0	450,000	33.8
	Total Uranium* pCi/l	15.0	0.19	14.8	450,000	6.7
1999/2000	Carbon Tetrachloride	92.0	ND	92.0	2,503,800	230.3
	Tetrachloroethene	86.5	1.00	85.5	2,503,800	214.1
	Trichloroethene	113.5	0.85	112.7	2,503,800	282.1
	Total Uranium* pCi/l	6.5	ND	6.5	2,503,800	16.3

* Avg. U-233, -234 + Avg. U-235 + avg. U-238

** U Isotopic data not broken out in 2002 Report

Water levels (hydraulic head) upgradient and downgradient of the collection system are compared as another indicator of the installed barrier's ability to intercept and collect groundwater in this area.

2.2.2.1 Upgradient Water Quality

The closest wells upgradient of the Mound Site Plume Treatment System had relatively low concentrations of VOCs in 2003. The highest VOC concentrations in Well 15399 were 72.2 micrograms per liter (ug/L) of cis-1,2-dichloroethene and 106 ug/L of TCE. Well 15499 had 107 ug/L of TCE and 118 ug/L of PCE. In accordance with the IMP, these two wells were not sampled in 2004.

Two upgradient wells, 91103 and 91203, were recently installed in the area of soil contamination associated with the Oil Burn Pit #2, IHSS 153. Groundwater in Well 91203 had relatively low concentrations of VOCs; the highest concentration was carbon tetrachloride at 126 ug/L. Well 91103, which is located within the source area, had groundwater VOC concentrations two orders of magnitude higher than Well 91203. In Well 91103, PCE was 18,100 ug/L, TCE was 10,800 ug/L, and 1,1,1-trichloroethane was 6,930 ug/L. Contaminant concentrations decline closer to the collection system and the influent concentrations do not reflect these higher contaminant concentrations. These wells were sampled again in 2004, and Well 91103 had similar concentrations with PCE at 19,700 ug/L, TCE at 10,800 ug/L, and 1,1,1-trichloroethane

at 8,630 ug/L. Well 91203 was sampled twice in 2004 and once in 2005; except for carbon tetrachloride, all VOCs were less than 15 ug/L. The highest concentration of carbon tetrachloride during this period was 143 ug/L. Aroclor-1254, a PCB, was detected on November 11, 2004 at concentrations less than the detection limit at an estimated concentration of 0.14 ug/L.

An additional well, 91104, was installed in 2004. This well was later replaced by well 91105 in 2005. This well is located in the Oil Burn Pit #2 (Figure 1). It was sampled on November 11, 2004 and again on January 26, 2005. In addition to high concentrations of chlorinated VOCs, Aroclor-1254 and hydrocarbons were present. The chlorinated VOCs were similar to Well 91103, except the concentrations were higher. The highest VOC concentrations were TCE at 84,800 ug/L, PCE at 76,200 ug/L, and 1,1,1-trichloroethane at 22,200 ug/L. Most hydrocarbons were below 150 ug/L except for toluene that had a high value of 311 ug/L. The hydrocarbons could be from kerosene or a similar fuel. The only PCB detected was Aroclor-1254, which ranged from 17.3 to 4,400 ug/L. As previously noted, source removal was conducted in this area in 2005. This should reduce the VOC concentrations over time.

Well 10197 is just upgradient of the gravel filled trench installed in March 2005, west of the collection trench. This well was sampled on January 26, 2005. The highest concentrations of VOCs were 909 ug/L of cis-1,2-dichloroethene, 342 ug/L of TCE, and 63.5 ug/L of PCE. All other VOC concentrations were below 50 ug/L.

2.2.2.2 Downgradient Water Quality

The collection system was installed near South Walnut Creek "to capture the contaminated groundwater to the extent practicable." Wells downgradient of the collection system are located within the portion of the plume that was not targeted for treatment.

In addition to well 3586, three wells were planned for sampling in accordance with the IMP, Wells 15799, 15599, and 15699. However, during 2003, Well 15799 did not contain sufficient water for sampling, and Wells 15599 and 15699 had sufficient water for only one sampling event during the year. In 2004, neither Well 15799 nor Well 15699 had sufficient water for sampling, and Well 15599 could only be sampled once. Radionuclides and VOCs were sampled on different dates in Well 15699 during the same springtime sampling event. Analytical results from these wells are provided in Tables 6 and 7.

Figures 3 and 4 show the concentration trends for the downgradient wells. Because of the variation in downgradient concentrations, continued IMP monitoring to confirm that concentrations are being reduced is anticipated.

Table 6. Mound Site Plume 2003 Downgradient Well Analytical Results

Analyte	Performance Monitoring Well 3586		Well 15599	Well 15699		RFCA GW Tier II AL	Units
	4/21/03	11/20/03	4/22/03	4/23/03	5/16/03		
Benzene	ND	0.54J	ND	ND	-	5	ug/L
Chloroform	ND	ND	0.69 J	ND	-	100	ug/L
1,1-Dichloroethane	ND	12.4	ND	ND	-	3650	ug/L
1,2-Dichloroethane	ND	0.34 J	ND	ND	-	5	ug/L
cis-1,2-Dichloroethene	ND	3.2	0.85 J	26	-	70	ug/L
trans-1,2-Dichloroethene	ND	0.43 J	ND	ND	-	70	ug/L
Tetrachloroethene	ND	ND	16.5	24	-	5	ug/L
Trichloroethene	ND	ND	21.1	37	-	5	ug/L
Vinyl Chloride	ND	2.9	ND	ND	-	2	ug/L
Plutonium-239/240	0.0166 J	ND	ND	-	ND	0.151	pCi/L
Uranium-233/234	1.82	1.52	4.97	-	16.6	1.06	pCi/L
Uranium-235	ND	0.33 J	0.696 J	-	0.544	1.01	pCi/L
Uranium-238	1.28	1.29	3.31	-	13.4	0.768	pCi/L

- =Not sampled

J = Detected at concentrations or activities below the detection limit for this analysis

ND = Not detected at the detection limit for this analysis

Table 7. Mound Site Plume 2004 Downgradient Well Analytical Results

Analyte	Performance Monitoring Well 3586	Well 15599	RFCA GW Tier II AL	Units
	4/15/04	4/27/04		
1,1-Dichloroethane	8.63	ND	3650	ug/L
cis-1,2-Dichloroethene	1.74	0.96 J	70	ug/L
Tetrachloroethene	0.56 J	17	5	ug/L
Trichloroethene	ND	30.1	5	ug/L
Americium-241	0.0142 J	-	0.145	pCi/L
Uranium-233/234	2.16	-	1.06	pCi/L
Uranium-235	ND	-	1.01	pCi/L
Uranium-238	1.47	-	0.768	pCi/L
Total Uranium	4.7B	-	-	ug/L

- =Not sampled

B = Result is below required detection limit but above instrument detection limit

J = Detected at concentrations below the detection limit for this analysis

ND = Not detected at the detection limit for this analysis

Figure 3. Mound Site Plume Downgradient TCE Concentrations

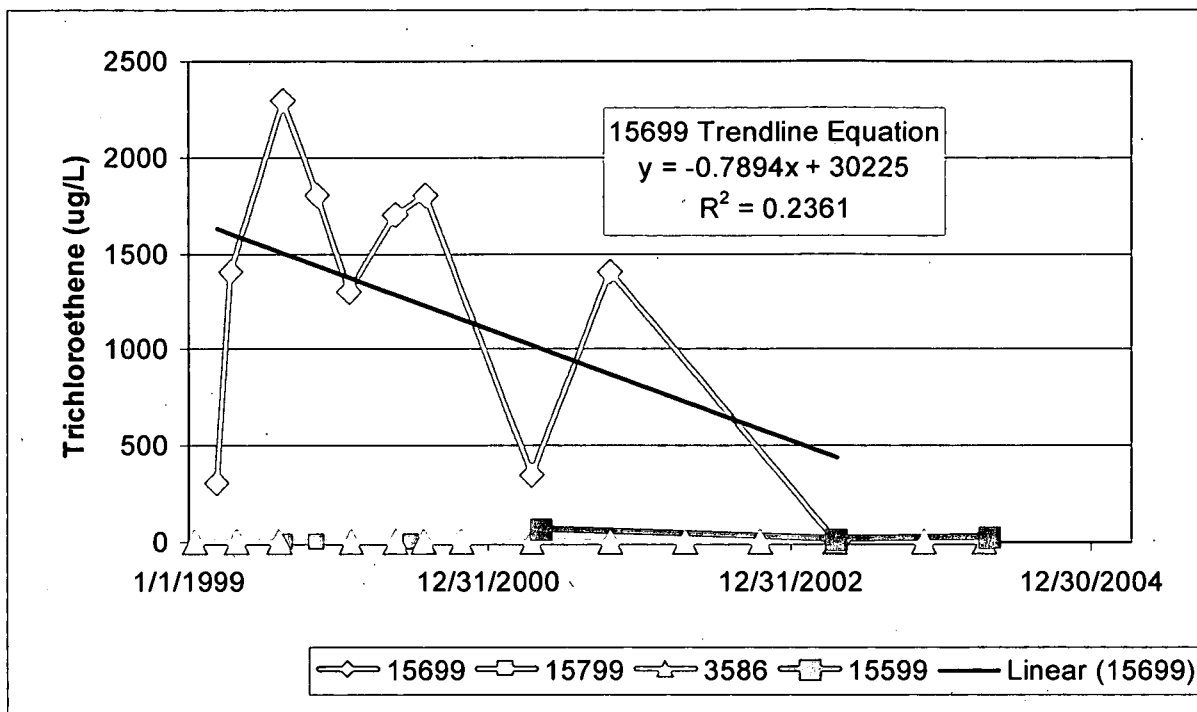
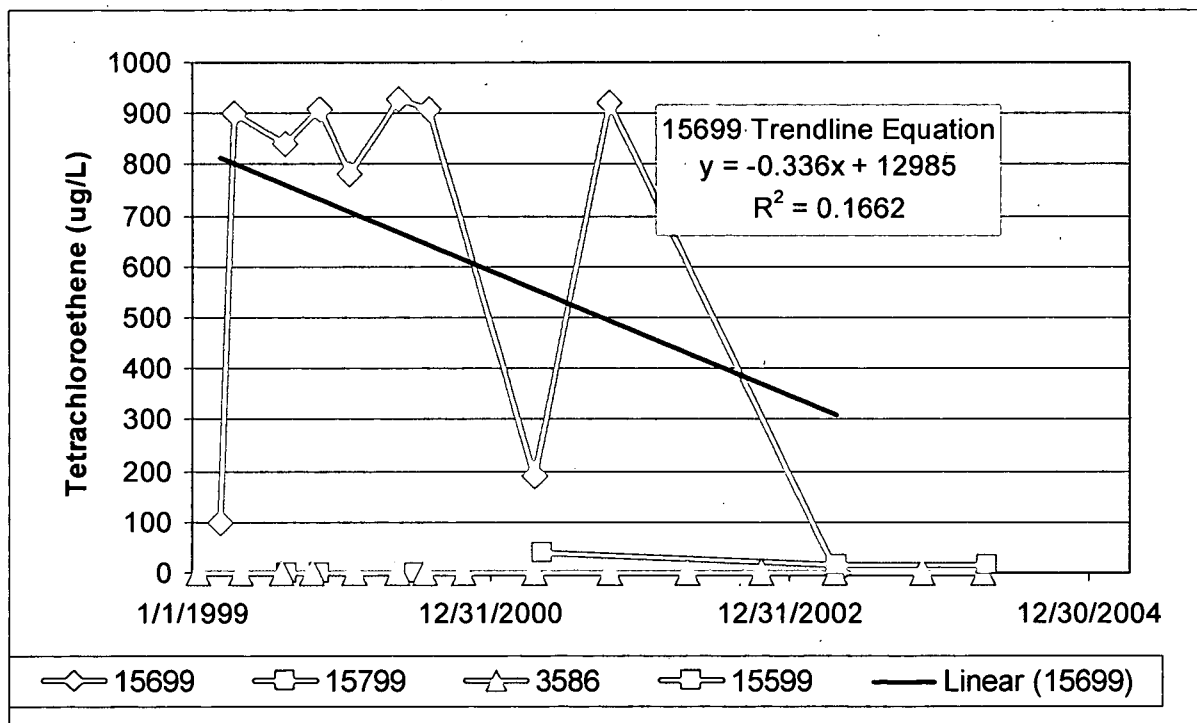


Figure 4. Mound Site Plume Downgradient PCE Concentrations



Cis-1,2-dichloroethene and vinyl chloride are degradation products of the primary groundwater contaminants in this plume. The low concentrations seen in the downgradient wells are probably a result of the residual, pre-existing plume and generally not a byproduct of the treatment

process. The treatment system is effective in removing uranium, and any uranium in the downgradient wells is a result of residual contamination or naturally occurring uranium.

Concentrations in the downgradient wells indicate that the residual contamination levels appear to be declining and that the collection system tends to mitigate downgradient plume concentrations. For example, concentrations at Well 15599, frequently dry in the past, have decreased since the previous sample collected in 2001. Although there is variability in the concentrations, a decrease in TCE concentrations was noted in Well 15699. PCE concentrations are more variable, and the downward trend is not as evident. This well is located within the preferential flow path for the Mound Site Plume and along the trend of the highest plume concentrations defined in the pre-remedial investigation (DOE 1997a).

Well 3586 continued to have low concentrations as it has had in the past. Statistical analysis of vinyl chloride in Well 3586 was performed using Seasonal Kendall trend testing and is presented in Appendix D of the Annual RFCA Groundwater Monitoring Report (K-H 2004a). The concentration was decreasing at the 95% confidence level for vinyl chloride.

2.2.2.3 Water Levels

Groundwater levels are used to indicate the hydraulic head within and adjacent to the collection and treatment system. Five piezometers (16199 through 16599) were monitored quarterly within the collection trench (Figure 1). The piezometer at the east end of the collection trench (Piezometer 16199) was dry throughout 2003 and 2004, as in the past. The water levels in the other piezometers were relatively consistent with one another in 2003, except in April when the groundwater elevations were approximately a foot higher than previously recorded observations. This is likely due to the heavy precipitation at the end of March that also correlated to increased flow rates within the treatment systems. The water levels in the western end of the trench (16599 and 16499) were slightly higher in 2004, which was likely due to upgradient flow. Groundwater elevations in the nearby wells were also elevated as described below.

Groundwater levels were monitored quarterly at seven locations surrounding the collection trench (three upgradient, three downgradient, and one to the east) as shown on Figure 1 and in Table 8. Groundwater elevations in the wells upgradient of the collection trench still showed drought effects in January 2003, but subsequently increased approximately three feet in 15399 and more than eight feet in 15499. Well 15299 has remained dry through 2003 and 2004 indicating that there is probably less upgradient flow to the treatment system to the east of the collection trench.

The groundwater elevations in wells downgradient of the trench recovered a little from the drought in Spring 2003; however, by Fall 2003, all three wells were dry again and remained relative low or dry throughout 2004. Seasonal water level fluctuations are approximately two to seven feet in upgradient and downgradient wells. Seasonal fluctuations were higher in 2003 because drought conditions in the beginning of the year, followed by a heavy snowstorm in March 2003. Groundwater elevations in Well 3586, near South Walnut Creek, remained within a few feet of the normal creek elevation of 5,903 feet in this area.

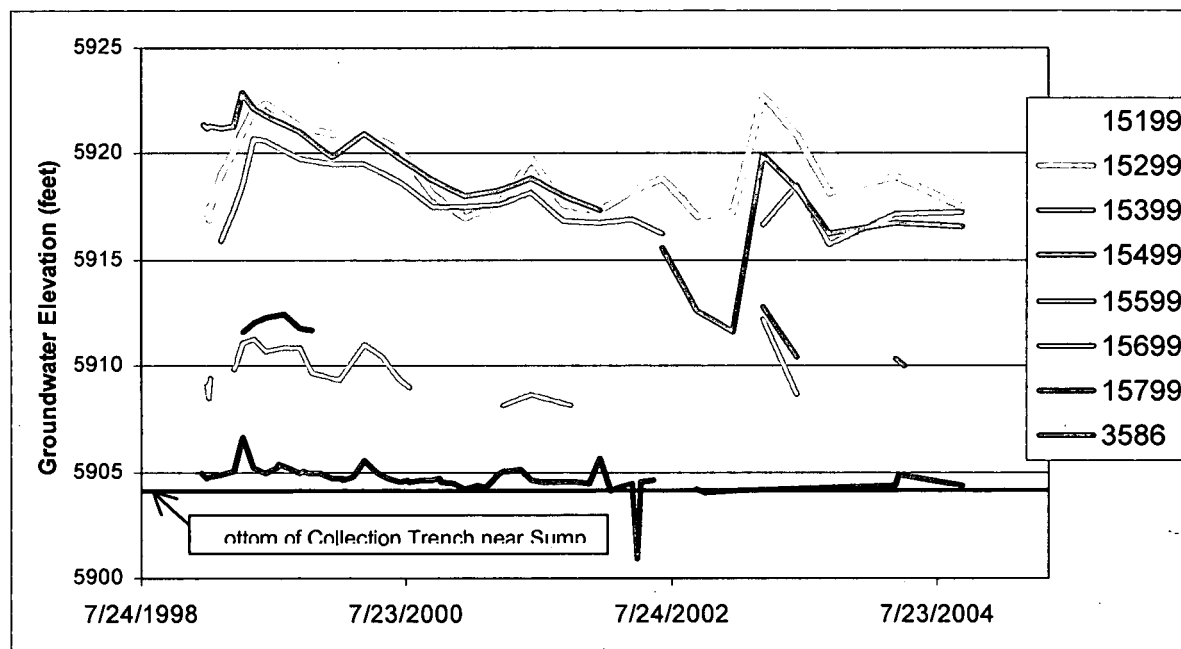
Water elevations are shown on Figure 5. A simplified conceptual model of groundwater flow near the collection trench is shown on Figure 6. The hydraulic gradient induced by the trench can be seen in the difference in water elevations driving the water from the edges of the capture area, toward the center of the downgradient portion of the plume.

Table 8. Mound Site Plume Upgradient and Downgradient Water Elevations (Feet Above Mean Sea Level [MSL])

Well Number	Location	01/08/03	04/08/03	07/02/03	10/02/03	4/1/04	10/5/04
15199	Eastern	5917.28	5922.76	5920.86	5918.21	5918.91	5917.55
15299	Upgradient	Dry	Dry	Dry	Dry	Tech Dry	Dry
15399	Upgradient	5913.86	5916.68	5918.55	5915.71	5917.2	5917.25
15499	Upgradient	Tech Dry	5919.91	5918.38	5916.26	5916.74	5916.57
15599	Downgradient	Dry	5912.79	5910.46	Tech Dry	5910.37	Dry
15699	Downgradient	5906.99	5912.24	Tech Dry	Tech Dry	Tech Dry	Tech Dry
15799	Downgradient	Dry	Dry	5911.92	Tech Dry	Dry	Dry

Tech Dry = Technically Dry, water level was below the screened interval

Figure 5. Mound Site Plume Water Elevations in Wells vs. Time

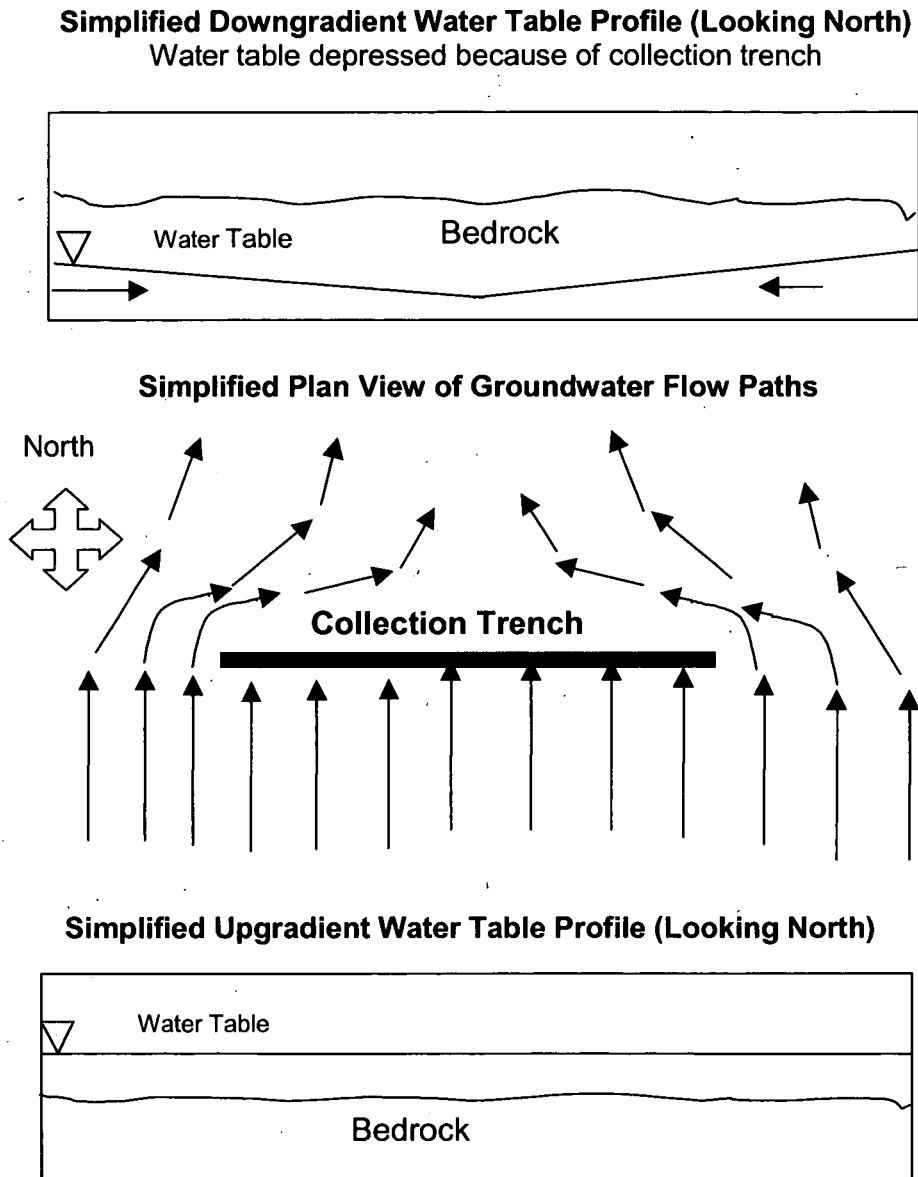


Note: Elevation of the collection trench base is 5904 to 5914 feet.

In January 2003, drought conditions greatly reduced the groundwater flow. As a result, the two outside downgradient wells, 15599 and 15799, were dry and the water level at 15699 was greatly reduced.

After the March 2003 precipitation event, a measurable water level was re-established at Well 15599 on the western side of the Mound Site Plume, but not at 15799. The increase in water levels was likely a result of the heavy snow pack melting and percolating downwards into the groundwater. The slope on the eastern side of the collection trench is flatter and may have allowed for more percolation into the soil. On the steeper sloped, western side of the collection trench, snowmelt is more likely to become run-off. By July, the downgradient groundwater profile returned to normal conditions illustrated on Figure 6. This is consistent with the intended design and indicates that the collection system is working effectively.

Figure 6. Conceptual Model of Groundwater Flow near the Mound Site Plume Collection Trench



2.3 Operations and Maintenance

During 2003 and 2004, system maintenance included raking the media in the treatment cells and system checks periodically over the course of the year. Media raking has been reduced because the crust formation continues to be minimal. The flow measurement flume was cleaned approximately three times and recalibrated five times in 2003. A more frequent flow meter maintenance schedule was established in 2004 because of plugging problems in the flume. In 2004, the flume and bubbler line were cleaned eight times and the flow meter was recalibrated six times. In 2003, Site personnel performed quarterly water level monitoring and semiannual analytical sample collection in accordance with Table 2 of the Mound Site Plume Decision

Document (DOE 1997a). In 2004, water level monitoring was reduced to semiannual measurements.

The ongoing treatment system maintenance, raking the iron media, retrieving flow rate and water level data, flow meter maintenance and calibration, and monitoring water quality, are the only necessary operational activities. Both the treatment system and downgradient wells will continue to be sampled on a semiannual basis, and water levels will be measured quarterly.

As described in the Mound Site Plume Decision Document (DOE 1997a), the media is anticipated to require replacement every 5 to 10 years. Based on performance to date, media replacement is anticipated to occur in 2008, after approximately 10 years of service.

2.4 Conclusions

The Mound Site Plume Treatment System is operating properly and successfully. The effectiveness of the Mound Site Plume Treatment System was evaluated by comparing the Mound Site Plume Decision Document Remedial Action Objectives to the system performance. These objectives are:

1. Intercept and treat contaminated groundwater, including seep SW059, at the distal end of the Mound Site Plume. Evaluated as collection system effectiveness (Section 2.4.1).
2. Design and install a passive groundwater treatment system that, to the extent practicable, protects surface water and reduces the contaminant mass loading in surface water consistent with the ALF. Evaluated as treatment system effectiveness (Section 2.4.2).

In addition, operation and maintenance information from approximately five years of operation, described in Section 2.3, is provided to allow further evaluation of overall effectiveness of this type of system for specific applications at RFETS.

2.4.1 Collection System Effectiveness

During construction, groundwater exiting at Seep SW059 was intercepted. This water is now captured by the Mound Site Plume Treatment System collection trench and treated along with contaminated groundwater captured from the plume. The collection trench continues to be effective in cutting off and recovering significant volumes of contaminated groundwater. In 2003, approximately 82,000 gallons of contaminated groundwater were captured and treated. In 2004, approximately 86,000 gallons of contaminated groundwater were captured and treated. These volumes are consistent with annual quantities collected and treated since the first year of operation.

In 2005, an evaluation of Mound Site Plume Treatment System groundwater capture was performed using the same integrated groundwater and surface water modeling software used for RFETS Site-wide modeling. A new model using a finer resolution was developed to determine whether the existing system configuration was sufficient to capture upgradient plumes, especially the plume associated with releases at Oil Burn Pit #2. In addition to groundwater data, the model took into consideration the horizontal and vertical extent of both the French drain and Mound Site Plume collection trench, the depth and location of the storm drain, and other subsurface structures that impact groundwater movement. Modeling results showed that the existing system was capturing the plume, including portions associated with the Oil Burn Pit #2. Additional details are presented in the Groundwater IM/IRA (DOE 2005a).

Performance monitoring well 3586 results continue to show groundwater contaminant concentrations for some detected VOCs and for some uranium isotopes are greater than RFCA Tier II Action Levels (ALs) downgradient of the Mound Site Plume Treatment System. These appear to be from residual contamination and naturally occurring uranium rather than contaminants that have bypassed the collection system. It is likely that concentrations in these areas are decreasing because of degradation and flushing by cleaner groundwater that is not captured by the collection trench. The downgradient plume area was evaluated as part of the Groundwater IM/IRA (DOE 2005a) and no additional accelerated action is required for this area.

Upgradient concentrations are not significantly reduced from levels observed prior to system installation, so the system continues to serve the function of intercepting contaminated groundwater. Therefore, Objective 1 is being met.

2.4.2 Treatment System Effectiveness

The Mound Site Plume Treatment System is effectively reducing the mass loading to surface water. Approximately 47 grams of VOC contamination were removed annually by the treatment system during 2003 and 2004, which appears consistent with removal rates in previous years. Effluent concentrations meet RFCA surface water ALs and standards. Therefore, Objective 2 is being met.

2.5 Planned Activities

Continued raking of the media, sampling and water level measures are planned for this system. It does not appear at this time that the media is losing any treatment capacity, and has several more years before replacement is needed.

3.0 EAST TRENCHES PLUME TREATMENT SYSTEM

The East Trenches Plume Treatment System was installed in 1999 in accordance with the Final Proposed Action Memorandum (PAM) for the East Trenches Plume (East Trenches Plume PAM) (DOE 1999b). System installation is documented in the Final East Trenches Plume Project Closeout Report, Fiscal Year 1999 (DOE 2000a).


The East Trenches Plume Treatment System collects and treats contaminated groundwater emanating from the area around Trench T-3 and Trench T-4. These trenches were the primary sources for the contaminated groundwater plume and were remediated in 1996 as an RFCA accelerated action, in accordance with the *Final Proposed Action Memorandum for the Source Removal at Trenches T-3 and T-4, IHSSs 110 and 111.1* (DOE 1996b). Installation of the 1,200-foot-long collection system, and two reactive iron treatment cells, similar to the Mound Site Plume Treatment System, was completed in September 1999. Treated water is discharged back into the groundwater on the downgradient side of the treatment cells through a discharge gallery designed to overflow to the surface when the surrounding soil is saturated. This overflow discharges to the surface immediately downgradient of the treatment cell near South Walnut Creek. Locations are shown on Figure 7.

Figure 7

Surface Water Drainage

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Standard Man Features

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☐ Lakes and ponds

--- Fences and other barriers

Paved roads

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structures from 1994 initially-over data captured by EG&G RSL, Las Vegas.

Topographic contours were derived from digitized logarithmic scale bathymetric data (1:50,000 scale) and DEM (DEM1) data by Marlowe, Kaula and Hancock using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was obtained by the Remote Sensing Lab, Las Vegas, NV, 1984. Acid Etch of ~ 10 m/s resolution, DEM post-processing performed by MKC Weber 1997.

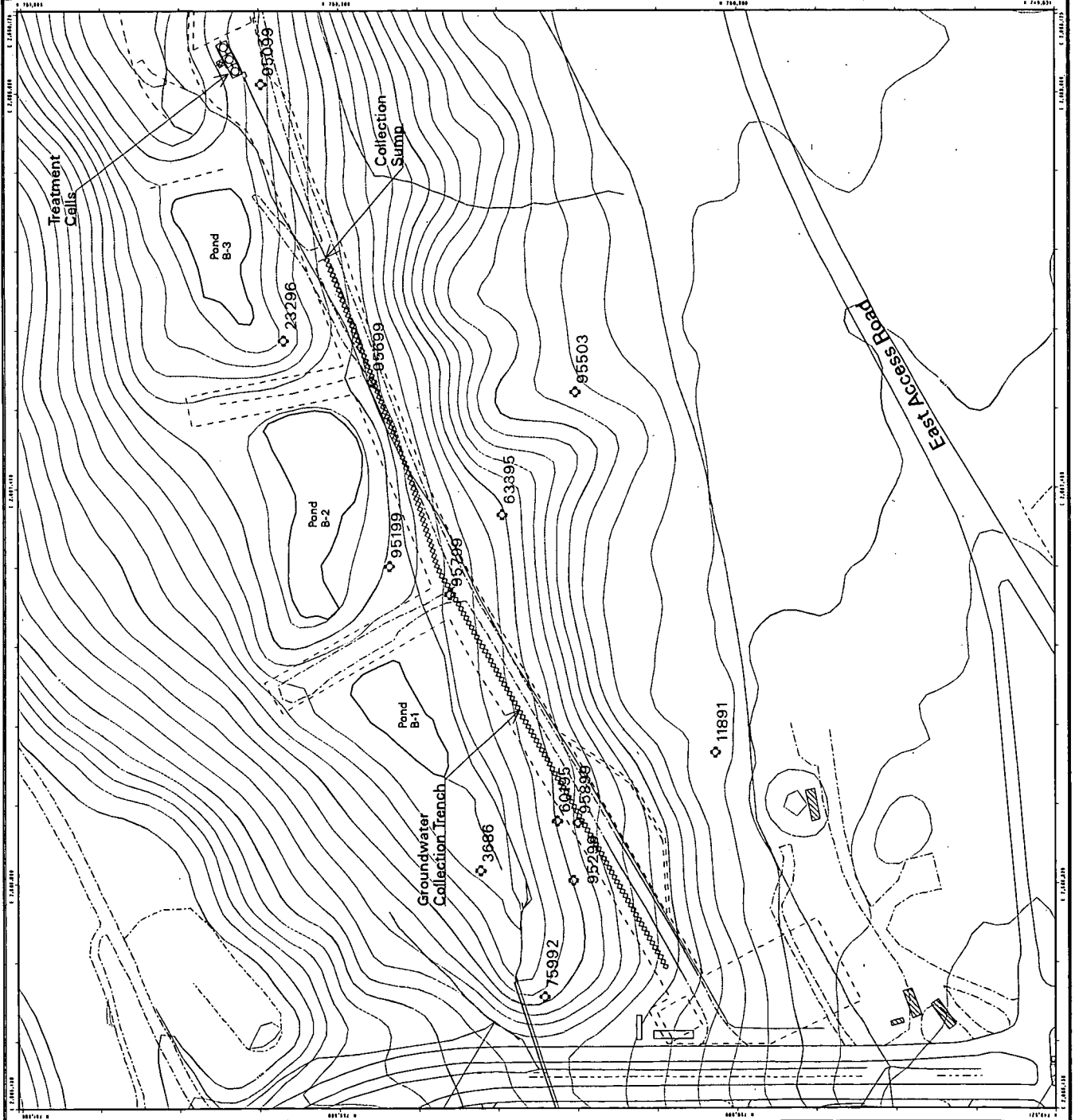
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3.1 Decision Document Objectives

In accordance with the East Trenches Plume PAM, the objectives for the East Trenches Plume Treatment System were to:

1. Intercept and treat VOC-contaminated groundwater at the distal end of the East Trenches Plume.
2. Protect surface water and reduce the VOC-contaminant mass loading in surface water, to the extent practicable.
3. Install an easily accessible system to reduce operation and maintenance costs and to easily replace media when necessary.
4. Minimize the impact to PMJM during construction.
5. Avoid depletion of waters to South Walnut Creek.

This report describes how Objectives 1 and 2 are met. It also provides information related to Objective 3. The other objectives were met during design and construction and are not specifically evaluated in this report.

3.2 Treatment Performance, Monitoring, and Maintenance

System performance monitoring locations and frequency required by the East Trenches Plume PAM are shown in Table 9.

Table 9. East Trenches Plume Treatment System Monitoring Requirements

Task	Month 1	Months 2-6	Months 7-12	Subsequent Years
Treatment System Influent	Monthly	Monthly	Monthly	Semi-Annually
Treatment System Effluent	Monthly	Monthly	Quarterly	Semi-Annually
Downgradient Water Quality	Quarterly	Quarterly	Quarterly	Semi-Annually
Hydraulic Head/Water Level Measurements	Monthly	Monthly	Quarterly	Semi-Annually

3.2.1 Treatment Performance

For the period January 1, 2003 through December 31, 2003, approximately 2.1 million gallons of groundwater was treated by the system. For the same period in 2004, approximately 1.5 million gallons were treated. The total volume of groundwater treated as of December 31, 2004, was approximately 9.3 million gallons. Daily average flow rates in 2003 ranged from 0.03 to 18.10 gpm, and averaged 4.23 gpm. Daily average flow rates in 2004 ranged from 0.27 to 17.34 gpm and averaged 2.85 gpm. With the Mound Site Plume Treatment System, the high flow rates correlate with periods of precipitation. The exception is the high flow rate in February 2003 that was most likely a result of water backing up in the flume from plugged discharge piping, causing a false, higher reading (Section 3.2.4).

Treatment system effectiveness is determined by comparison of the influent and effluent contaminant concentrations. A summary of these sampling events is provided in Tables 10 and 11. The contaminants of concern (COC) for this plume are primarily TCE, PCE and carbon tetrachloride; however, other contaminants are detected at lower concentrations. As shown in Tables 10 and 11, the treatment system is effectively removing VOCs. However, the surface water standards for PCE, TCE, and methylene chloride were not met consistently.

The treatment system functioned better in 2004 than 2003; however, methylene chloride is still a persistent concern. Methylene chloride was also present in many of the laboratory blanks so the actual frequency of detection and concentrations might be lower. Of 29 different effluent samples, 15 samples had methylene chloride in the associated laboratory blank. Because the zero-valent iron is not as effective on methylene chloride, it is unlikely that all of the methylene chloride is from cross-contamination. Although methylene chloride is a concern, successfully removing carbon tetrachloride even though there is a small amount of residual methylene chloride is more effective than not treating carbon tetrachloride. Methylene chloride is more readily degraded in the environment than carbon tetrachloride, being susceptible to both chemical and biological degradation. In addition, because of its volatility, most of the small amount in the effluent is likely volatilized or degraded prior to reaching surface water.

Table 10. Summary of East Trenches Plume 2003 Sample Results

Compound	Influent Concentration (ug/l)		Effluent Concentration (ug/l)					RFCA Tier II Groundwater AL (ug/l)	RFCA Surface water AL (ug/l)
	4/17/03	11/20/03	4/17/03	9/3/03	9/22/03	11/13/03	11/20/03		
Acetone	ND	ND	ND	ND	ND	ND	15	3,650	3,650
Benzene	ND	ND	0.5 J	0.41J	0.4J	ND	0.22J	5	5 [†]
2-Butanone	ND	ND	ND	ND	5.3J	ND	ND	21,900	21,900
Carbon Tetrachloride	120	160	ND	ND	ND	ND	ND	5	5 [†]
Chloroform	68	73	7.1	20	7.53	ND	ND	100	5.7
Cis-1,2-Dichloroethene	28	33	36	32.3	46	2.82	4.5	70	70
1,1-Dichloroethane	ND	ND	1.5	1.2	0.82J	0.41J	0.41	3,650	3.65
1,1-Dichloroethene	3.9J	5J	1.6	3	1.4J	0.21J	0.24J	7	7 [†]
Methylene Chloride	ND	ND	6.4B	19B	11.7	15.7	17	5	4.7
Tetrachloroethene	290	380	19	73	57.3	1J	1.3	5	5 [†]
Toluene	ND	ND	0.23J	0.18J	ND	ND	2.23	1,000	1,000
1,1,1-Trichloroethane	4.3J	4.7J	ND	ND	ND	ND	ND	200	200
Trichloroethene	2000*	2700*	60	200	77.4	4.62	5.7	5	5 [†]

B = Detected in laboratory blank

J = Detected at concentrations below the detection limit for this analysis

ND = Not detected at the detection limit for this analysis

* = Concentration exceeds RFCA Tier I Groundwater AL

† = Temporary modifications in effect through 2009

Elevated levels of PCE and TCE in effluent appear to be the result of lost pore space and a slight loss in removal efficiency. As the system is used, precipitates, and bacteria slowly cover the surface of the iron, its ability to effectively treat organics is reduced. In addition, mineral precipitation and bacterial growth also plug the pore spaces further reducing the capacity of the zero-valent iron bed. In April 2004, it was not known that the treatment media capacity was beginning to diminish; however, by September, plugging in the iron was preventing operation of the system and the iron was replaced. September analytical results reaffirmed that the zero-valent iron had reached the end of its usefulness. Plugging and iron replacement is described further in the Operations and Maintenance section.

The approximate contaminant mass removed is shown in Table 12 and was calculated based on the total measured flow and the midpoint of the contaminant concentration range shown in Tables 10 and 11. Previous years are included for comparison. Table 12 shows that reduction in mass loading to the stream is being achieved (Remedial Objective 2). The system was installed in 1999 and about 21,000 grams per year of VOCs are removed.

Table 11. Summary of East Trenches Plume 2004 Sample Results

Compound	1/28/04	2/25/04	3/22/04	5/26/04	6/22/04	7/29/04	8/19/04	10/20/04	RFCA Tier II Groundwater AL (ug/L)	RFCA Surface water AL (ug/L)
Influent Concentration (ug/L)										
Acetone	ND	77J	340	ND	ND	13.7	7J	ND	3,650	3,650
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	5	5 [†]
Carbon Tetrachloride	130	150	180	216	130	142	68.1	160	5	5 [†]
Chloroform	71	71	71	65.1	59	54.1	26.6	72.9	100	5.7
Cis-1,2-Dichloroethene	40	40	39	28	29	29.4	13.3	32.6	70	70
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	3,650	3.65
1,1-Dichloroethene	5	4.8J	4.8J	2.93	3.2J	3.3	1.6	4.21	7	7 [†]
Naphthalene	ND	ND	ND	ND	ND	ND	0.44J	ND	1460	28
Methylene Chloride	ND	2.7JB	2.6JB	ND	6.7JB	2.3	ND	ND	5	4.7
Tetrachloroethene	290	270	270	618	240	354	137	230	5	5 [†]
Toluene	ND	ND	ND	ND	ND	0.52JB	ND	ND	1,000	1,000
1,1,1-Trichloroethane	4.3J	4.5J	4.8J	4.79	3.9	1.7	4.55	4.3J	200	200
Trichloroethene	2300*	2400*	2400*	5510*	1900*	1960*	774*	1170*	5	5 [†]
Effluent Concentration (ug/L)										
Acetone	3.1J	4.2J	ND	ND	3J	24.2	16.8	ND	3,650	3,650
Benzene	0.27J	0.25J	0.27J	ND	0.33J	0.36J	0.33J	ND	5	5 [†]
Carbon Tetrachloride	ND	ND	ND	ND	ND	ND	ND	ND	5	5
Chloroform	1.1	1.4	1	ND	ND	ND	ND	2.56	100	5.7
Cis-1,2-dichloroethene	9.5	10	9.7	11.5	8	7.7	7.4	11.3	70	70
1,1-Dichloroethane	0.83J	0.88J	0.87J	ND	0.59J	ND	0.62J	ND	3,650	3.65
1,1-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	7	7 [†]
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	1460	28
Methylene Chloride	20	19B	21	17	14B	14.1B	13.7	15.6	5	4.7
Tetrachloroethene	0.93J	1.1	1.2	3.38	1.9	1.8	1.2	2.13	5	5 [†]
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	1,000	1,000
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	200	200
Trichloroethene	1.8	2.5	1.8	6.36	1.8	0.69J	0.55J	1.91	5	5 [†]

* = Concentration exceeds RFCA Tier I Groundwater AL

B = Detected in laboratory blank

J = Detected at concentrations below the detection limit for this analysis

† = Temporary modifications in effect through 2009

ND = Not detected at the detection limit for this analysis

Table 12. East Trenches Plume System Approximate Contaminant Mass Removed

Year	Contaminant	Influent (ug/l)	Effluent (ug/l)	Removed conc. (ug/l)	Volume Treated (liters)	Total Mass Removed (g)
2004	Carbon Tetrachloride	142	ND	142.1	5,708,400	810.9
	Tetrachloroethene	377.5	2.16	375.3	5,708,400	2,142.6
	Trichloroethene	3,142	3.46	3,138.5	5,708,400	17,916.1
2003	Carbon Tetrachloride	140	ND	140	7,949,400	1,112.9
	Tetrachloroethene	335	37	298	7,949,400	2,368.9
	Trichloroethene	2,350	102.85	2247.15	7,949,400	17,863.5
2002	Carbon Tetrachloride	176	ND	175.5	3,785,400	664.3
	Tetrachloroethene	324	6.73	316.8	3,785,400	1,199.1
	Trichloroethene	2,540	2.46	2,537.5	3,785,400	9,605.6
2001	Carbon Tetrachloride	160	ND	160.0	7,192,300	1,150.8
	Tetrachloroethene	300	2.95	297.1	7,192,300	2,136.5
	Trichloroethene	2,700	0.33	2,699.7	7,192,300	19,416.8
1999/ 2000	Carbon Tetrachloride	185	-	185.0	10,599,200	1,960.9
	Tetrachloroethene	370	1.00	369.0	10,599,200	3,911.1
	Trichloroethene	3,600	1.00	3,599.0	10,599,200	38,146.5

3.2.2 Groundwater Monitoring

In accordance with the East Trenches Plume PAM (DOE 1999b), three downgradient wells (95099, 95199, and 95299) were installed during construction. These wells, along with Well 23296, are used to monitor the ability of the groundwater collection system to control plume expansion and potential increases in plume contaminant concentrations. These wells are shown on Figure 7 and monitoring results are provided in the following sections. The groundwater quality monitoring results for certain wells upgradient of the barrier are also included to allow comparison with treatment cell influent concentrations and to monitor for possible effects of changes in groundwater flows and contaminant concentrations due to the barrier. The sampling regime for these other groundwater-monitoring wells is specified in the IMP for 2003 (DOE 2003).

3.2.2.1 Upgradient Water Quality

Wells 11891 and 95503 are located upgradient of the collection and treatment system. In 2003, the contaminants in Well 11891 were carbon tetrachloride at 196 to 447 ug/L, PCE at 131 to 193 ug/L, and TCE at 25.3 to 41.4 ug/L. Well 11891 was sampled only once in 2004 (on May 25, 2004) and had 0.93 ug/L 1,1,1-trichloroethane, 1.34 ug/L 1,1-dichloroethene, 780 ug/L carbon tetrachloride, 13.2 ug/L chloroform, 30.7 ug/L cis-1,2-dichloroethene, 410 ug/L PCE, and 47.5 ug/L TCE. Well 95503 was not sampled in 2003. It had very low concentrations of carbon tetrachloride (0.76 ug/L) and acetone (22 ug/L) in February 2004. A sample collected in May 2004 did not have detectable quantities of any VOCs.

Carbon tetrachloride and PCE concentrations at these upgradient wells are the same order of magnitude as the treatment system influent. TCE at these well locations appears to be two orders of magnitude lower than the influent. It appears that the collection barrier intercepts an area of TCE at higher concentrations than indicated by well results. While this mitigates potential impacts from this contamination, it also may lower the expected treatment media life.

Bench scale testing of the treatment system design, as described in the East Trenches Plume PAM (DOE 1999b), was based on a VOC loading of 5.2 grams/day, or about 1,900 grams/year. While the bench scale testing showed that high concentrations of VOCs are effectively treated using this media, the gram loading observed to the treatment system for TCE alone is much higher than 1,900 grams/year.

3.2.2.2 Downgradient Water Quality

Table 13 shows the CDPHE surface water sampling results from Pond B-2, downgradient of the collection system. The Pond B-2 south sample is closest to the collection system (Figure 7).

Grab samples collected in March 2003 from Pond B-2 show significantly higher VOC concentrations than other sampling events. These samples were collected in the winter and ice on the pond probably reduced volatilization. These results are also much higher than what has been previously observed in adjacent groundwater Well 95199.

Dibromochloromethane was detected in the pond water. It is a disinfectant by-product normally associated with chlorinated water; typically treated domestic water. Its presence suggests that some of the contamination might have come from a different source other than groundwater, although there is no readily apparent chlorinated water source. Treated sewage is an unlikely source because this pond is isolated from the drainage and did not receive effluent from the Building 995 waste water treatment plant.

Except for the presence of dibromochloromethane and vinyl chloride, both samples collected from Pond B-2 in March 2003 are consistent with what would be expected in groundwater adjacent to the pond. Differences are generally caused by degradation that is likely occurring in this zone at a higher rate than in the area of the groundwater wells. However, the presence of vinyl chloride is unusual because it has not been found in surrounding wells. It is present in extremely low concentrations and is probably formed by degradation of dichloroethene. It is not apparent why the vinyl chloride did not further degrade in the pond sediments or become more diluted from the pond water; however, the samples were collected at the edge of the pond where contaminated groundwater is daylighting. It is possible that not much mixing is occurring in this area.

In November 2004, the B-Ponds dewatering began. In early 2005, 15-18 feet of sediments was excavation from Ponds B-1, B-2, and B-3 (DOE 2005d). In March 2005, during the excavation of Pond B-2, groundwater flow was observed at the southern side of the excavation. Two samples of the inflowing groundwater were collected and sent for analysis. The water contained low concentrations of VOCs, much less than would be expected from even the downgradient plume. The highest chlorinated VOC detected in one sample was TCE at 3.6 ug/L. The other sample did not have detectable quantities of any VOCs.

Table 13. CDPHE Pond B-2 Sampling Results

Pond B-2 North						
Analyte	10/22/2002	3/5/2003	5/29/2003	9/24/2003		Surface Water AL (ug/L)
Carbon Tetrachloride	ND	ND	ND	ND		5 [†]
Chloroform	ND	0.9	ND	ND		5.7
Dibromochloromethane	ND	2.5	ND	ND		80
1,1-Dichloroethene	ND	ND	ND	ND		7 [†]
cis-1,2-Dichloroethene	1.2	6	0.8	1.1		70
Trans-1,2-Dichloroethene	ND	ND	ND	ND		100
Tetrachloroethene	ND	2.4	ND	ND		5 [†]
Trichloroethane	ND	ND	ND	ND		200
Trichloroethene	ND	19	0.5	0.8		5 [†]
Trihalomethanes	ND	ND	ND	ND		80
Vinyl Chloride	ND	0.8	ND	ND		2
Pond B-2 South						
Analyte	10/22/2002	3/5/2003	5/29/2003	9/24/2003	6/28/2004	Surface Water AL (ug/L)
Carbon Tetrachloride	ND	5.3	ND	ND	ND	5 [†]
Chloroform	ND	12	ND	ND	0.6	5.7
Dibromochloromethane	ND	2.5	ND	ND	ND	80
1,1-Dichloroethene	ND	ND	ND	ND	ND	7 [†]
cis-1,2-Dichloroethene	7.9	41	2.9	2.7	15.4	70
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	100
Tetrachloroethene	ND	60	ND	ND	1.8	5 [†]
Trichloroethane	ND	0.6	ND	ND	ND	200
Trichloroethene	2.2	400	2.4	1.1	12.7	5 [†]
Trihalomethanes	ND	ND	ND	ND	ND	80
Vinyl Chloride	2.7	2.9	ND	4.6	9.9	2

ND = Not detected above detection limits

[†] = Temporary modification in effect through 2009

Analytical results for the downgradient wells are shown in Table 14. Well 95299 remained dry throughout 2003 and 2004, as it has been in previous years. Wells 23296, 95099, and 95199 contained sufficient water for the scheduled semiannual sampling. However, when insufficient groundwater was present to collect the full suite of samples at one time, the VOC analyses were prioritized over the radiological sampling because of the smaller sample volume required.

VOC concentrations in both Wells 23296 and 95199 exceed RFCA Tier II Groundwater ALs, but are much lower than the concentrations seen in the influent. These two wells are located within the downgradient portion of the plume that is not collected by the system.

Well 95199 is downgradient of the collection system and upgradient of Pond B-2. Figure 8 shows the concentration of TCE in Well 95199 over time. No other contaminants present at this well are significantly greater than detection limits. Contaminant concentrations fluctuate,

potentially due to groundwater flow from Pond B-2. There appears to be an upward trend but there is too much variability in the data to confirm it.

Table 14. East Trenches Downgradient Well Analytical Results

Analyte	Well Location							RFCA Tier II Ground- water AL	Unit
	23296								
	5/6/03	6/24/03	7/17/03	12/2/03	5/12/04	11/9/04	1/20/05		
Americium 241	0.00564 J	-	-	ND	-	-	-	?	pCi/L
Acetone	10	ND	ND	ND	ND	ND	ND	3,650	ug/L
Carbon Tetrachloride	2	ND	0.72	24.8	8.4	12.2	8.15	5	ug/L
Chloroform	2	ND	0.94	21.1	9.53	12.4	10.4	100	ug/L
Cis-1,2-Dichloroethene	12	97.8D	93	85.2D	137	162	110	100	ug/L
Tetrachloroethene	4	14.1	5.92	19.6	10.7	16.6	12.2	5	ug/L
Trichloroethene	94	86.6D	112	408D	343D	319D	434D	5	ug/L
Uranium-233,234	15.5	-	-	15.4	18.6	-	-	1.06	pCi/L
Uranium-235	1.39	-	-	0.571J	1.45	-	-	1.01	pCi/L
Uranium-238	11.9	-	-	11.8	12.9	-	-	0.768	pCi/L
Total Uranium	28.79	-	-	27.77	32.95	-	-	-	pCi/L
Total Uranium	ND	34.5	36.2	37.9	50.8 BN	40.8	-	-	ug/L
	95099								
	4/17/03		11/24/03		5/25/04		10/26/04		
Tetrachloroethene	ND		3		ND		ND		5 ug/L
Trichloroethene	ND		1.3		ND		ND		5 ug/L
	95199								
	4/21/03		11/24/03		5/25/04		10/26/04		
1,1-Dichloroethane	ND		1.5		1.31		1.29		3650 ug/L
1,1-Dichloroethene	ND		0.58		ND		1.17		7 ug/L
Cis-1,2-Dichloroethene	ND		2		1.88		1.5		100 ug/L
Tetrachloroethene	0.82J		4.8		3.07		2.01		5 ug/L
Trichloroethene	30.3		85.1		88.2		64.8		5 ug/L

- = Not sampled

BN = Estimated valued detected below the required detection limit

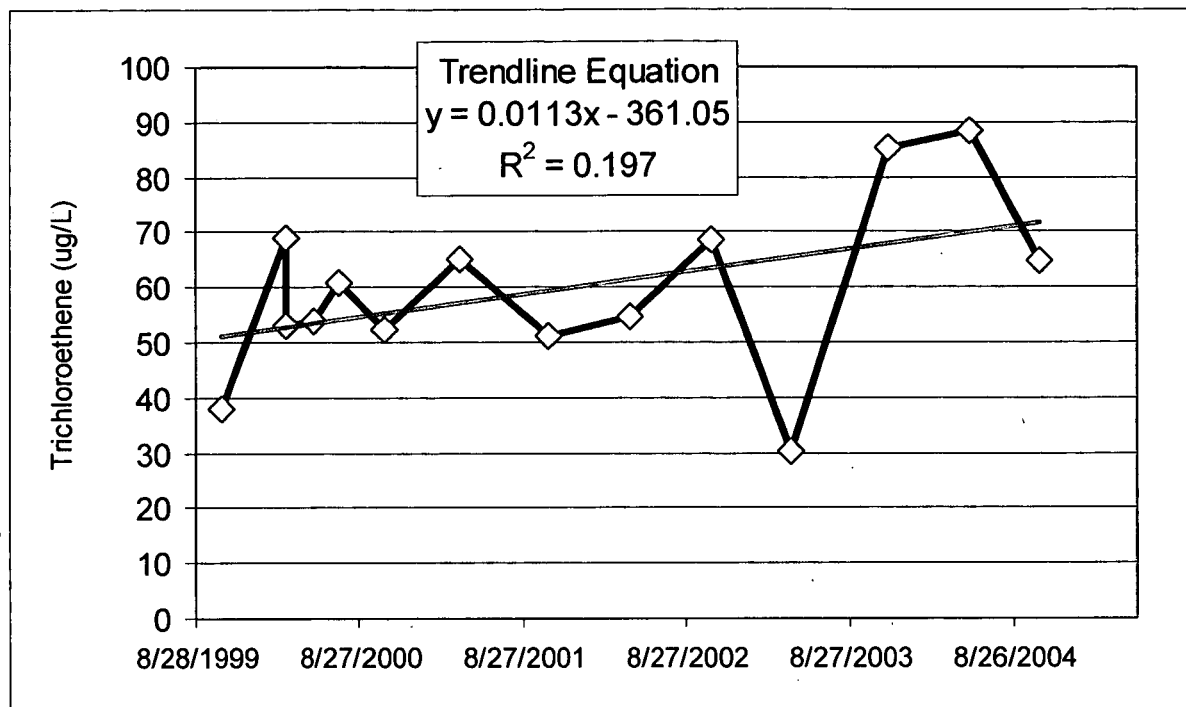
D = Diluted

J = Detected at concentrations below the detection limit for this analysis

ND = Not detected at the detection limit for this analysis

* = Concentration exceeds RFCA Tier I Groundwater AL

Figure 8. TCE Concentration in Well 95199



Well 23296 is located near Pond B-3, where the East Trenches Plume discharges to surface water. Higher VOC concentrations observed at this well were an early indication that a remedial action should be considered for this plume. As shown in Table 11, VOC concentrations at Well 23296 exceed RFCA Tier II groundwater ALs. In the past, VOC concentrations also exceeded Tier I groundwater ALs at this well.

Groundwater TCE concentrations at Well 23296 vary significantly (Figure 9). Figure 10 shows the sample results after the treatment system was installed. Contaminant concentrations in 2003 are lower than in the past; however, 2004 concentrations were similar to previous concentrations. While there appears to be a slight downward trend, the data variation does not support a definite conclusion. Figures 11 and 12 show similar trends in PCE concentrations. IMP monitoring is expected to continue at this location to determine if there is a downward trend in concentrations. Additional statistical analysis of groundwater trends using Seasonal Kendall trend testing is presented in Appendix D of the Annual RFCA Groundwater Monitoring Report (K-H 2004a).

Well 95099 is located east of the collection system, outside of the plume boundary. It was installed to monitor whether the plume would expand east as a result of installation of the collection system. Until November 2003, contaminants were not detected at this location. In November 2003, two of the three primary contaminants were detected in this well at low concentrations, below RFCA groundwater ALs. No VOC contaminants were detected in this well in the two samples taken in 2004.

Figure 9. Historical TCE Trend in Well 23296

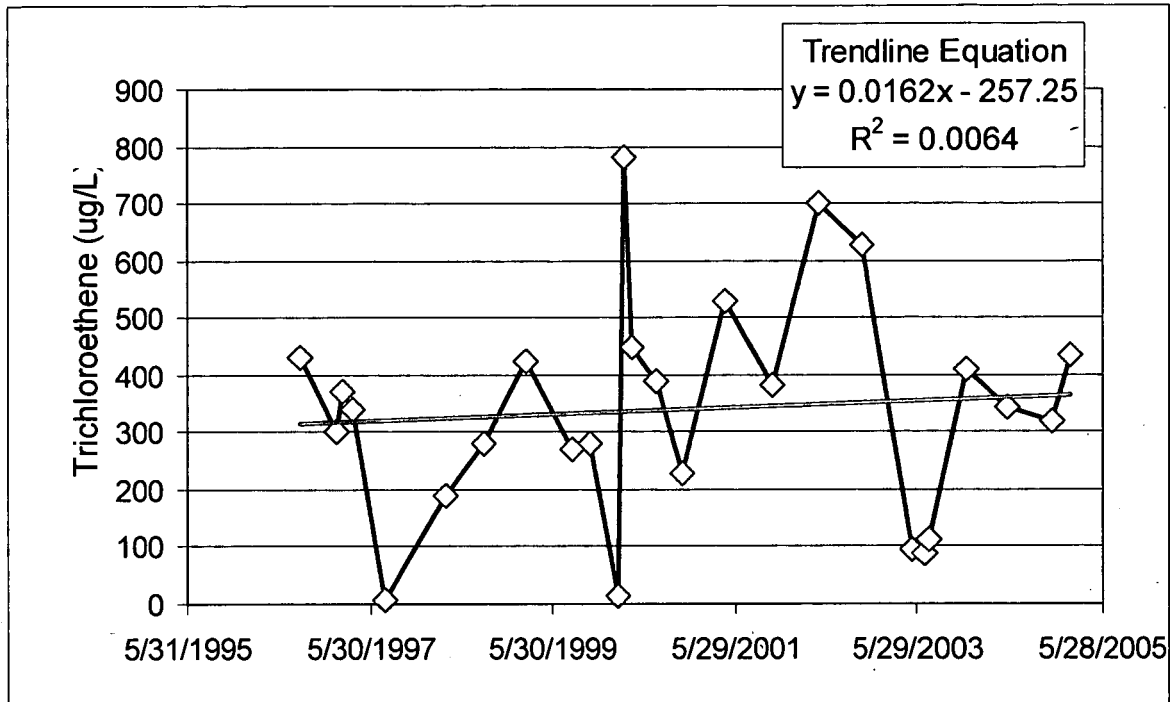


Figure 10. TCE Levels in Well 23296 During System Operation

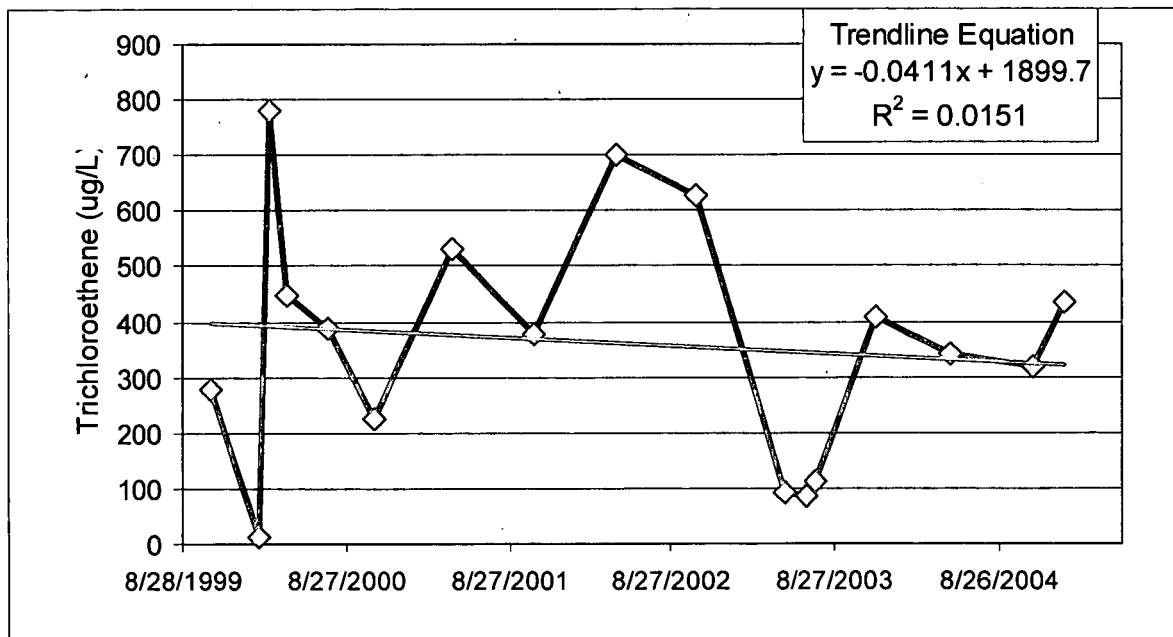


Figure 11. Historical PCE Trend in Well 23296

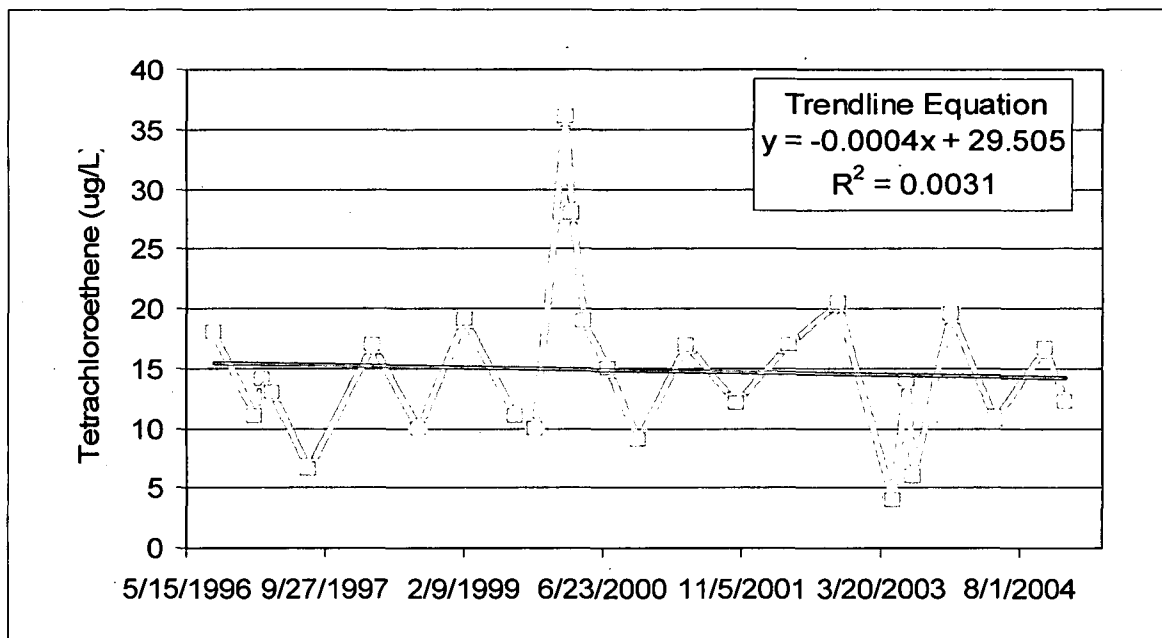
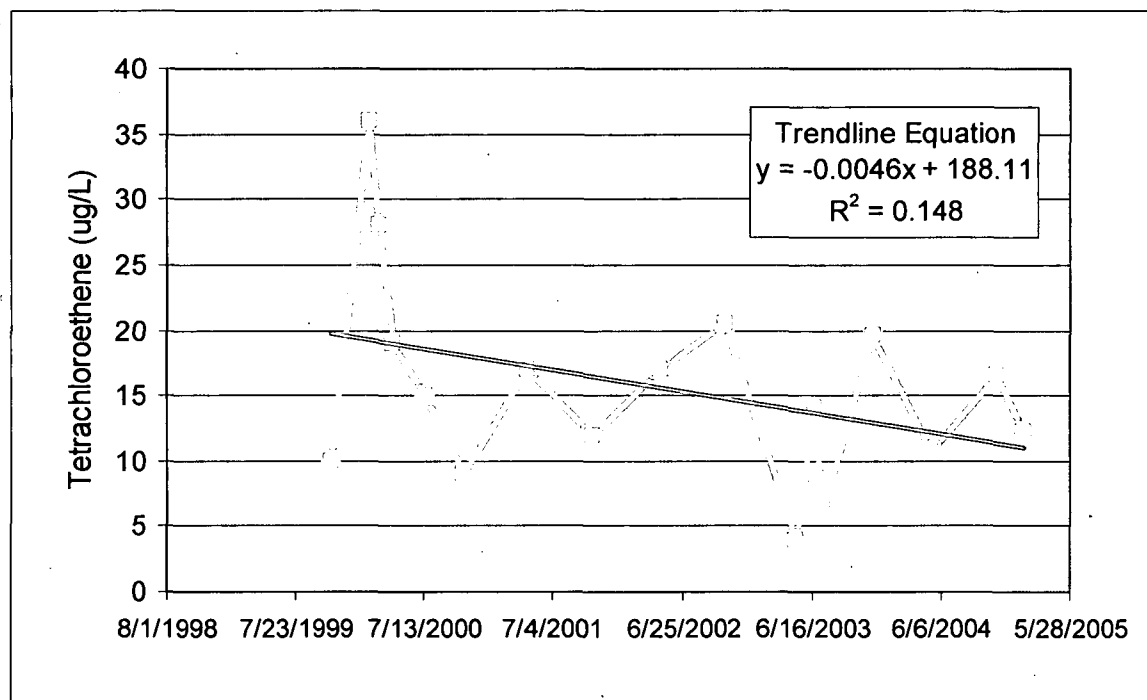


Figure 12. PCE Levels in Well 23296 During System Operation



3.2.2.3 Water Levels

Water levels within and downgradient of the collection trench were measured quarterly in 2003 because of the consistent water level elevations. In 2004, water levels were measured semiannually; however, at some locations additional measurements were made because of additional sampling or requests. Monitoring results are presented in Tables 15 and 16. Groundwater elevations in wells, piezometers, and associated B-Ponds are shown on Figure 13.

Table 15. 2003 East Trenches Plume Water Levels (Feet Above MSL)

Well	Location	01/06/03	04/07/03	07/02/03	10/03/03
23296	Downgradient	5851.76	5852.69	5851.61	5851.54
60195	Downgradient	Dry	Dry	Dry	Dry
63395	Upgradient	Dry	5891.61	5893.44	NM
75992	Downgradient	5887.87	5893.9	5889.37	Dry
95099	Eastern	5848.85	5849.21	5849.21	5849.41
95199	Downgradient	5869.04	5869.74	5870.69	5869.63
95299	Downgradient	Dry	Dry	Dry	Dry
95699	Collection Trench	Dry	Dry	Dry	5868.57
95799	Collection Trench	5876.26	5881.76	5884.82	5880.81
95899	Collection Trench	Dry	5888.75	5888.78	5888.74

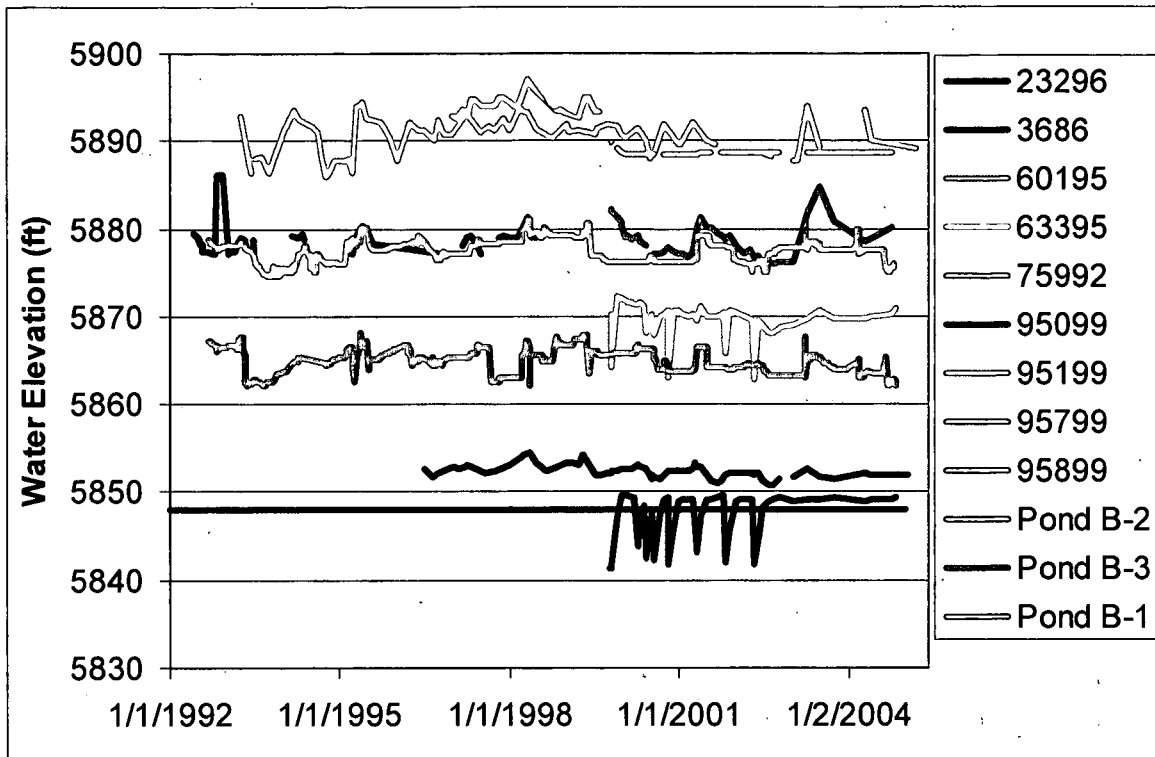
NM = not measured

Table 16. 2004 East Trenches Plume Water Levels (Feet Above MSL)

Well	Location	04/04	05/04	08/04	10/04	11/04	12/04	1/20/05	03/05
23296	Downgradient	5852.29	5852.06	5851.95	5851.94	5851.9	NM	5851.9	NM
60195	Downgradient	Dry	NM	NM	NM	NM	NM	NM	Dry
63395	Upgradient	5891.81	NM	Dry	NM	NM	NM	NM	NM
75992	Downgradient	5893.61	5890.09	NM	NM	NM	NM	NM	5889.21
95099	Eastern	5849.01	5849.09	NM	5849.23	NM	NM	NM	NM
95199	Downgradient	5869.76	5869.9	NM	5870.29	NM	NM	NM	NM
95299	Downgradient	Dry	Dry	NM	Dry	NM	Dry	NM	NM
95699	Collection Trench	Dry	NM	NM	Dry	NM	NM	NM	NM
95799	Collection Trench	5878.61	NM	NM	5880.07	NM	NM	NM	NM
95899	Collection Trench	5888.73	NM	NM	5888.77	NM	NM	NM	NM

NM = not measured

Figure 13. East Trenches Plume System Water Elevations



Three wells are immediately downgradient of the collection trench and one well is located east and downgradient of the collection trench (Figure 7). These wells continue to demonstrate there is a strong gradient downward to the northeast. Well 95299 is always dry, providing evidence that there is no groundwater flow from the ponds or from groundwater bypassing the trench in this area.

Well 23296 is adjacent to Pond B-3 and shows less water level fluctuation probably because its water level is dominated by the water levels in Pond B-3. Pond B-3 pond water is held at a near constant elevation by its discharge pipe.

At Well 95199, located downgradient of the middle of the collection trench, groundwater elevations appear to be influenced by Ponds B-1, B-2, and South Walnut Creek. These ponds are isolated from the main drainage system and only collect local area drainage. Pond water is usually not discharged, but is allowed to evaporate or infiltrate into the ground. Therefore, water levels rise in these ponds because of precipitation events. The fluctuations seen in the groundwater elevations for Well 95199 also appear to be the result of precipitation events and reflect the influence of Pond B-2 on this area. The higher water levels in this well indicate that there may be some groundwater flow towards the collection trench from the north. As shown on Figure 13, the gradient appears to change direction over time, sometimes flowing from Pond B-2 to the well and towards the collection trench.

The groundwater elevation at Well 95099, located east of the collection trench, fluctuated the most, from 5,842 to 5,850 feet above MSL. It is likely that this well is strongly influenced by precipitation events.

A recent concern was whether a high permeability zone encountered near Pond B-2 during trench installation might be a conduit for flow beneath the trench. When the collection trench was installed, there was flow into the excavation from both the upgradient and downgradient side of the trench. This suggests that the hydraulic gradient on both sides of the collection trench is locally towards the trench. Groundwater flow from the downgradient side is likely a result of water stored in the B-Ponds. If the high permeability zone is acting as a conduit and was not cut off during collection trench installation, it could be bringing in pond water, not transporting contaminated groundwater downgradient. The elevation of the collection trench in this area is lower than the water level in the ponds, supporting this interpretation.

3.3 Operation and Maintenance

During 2003 and 2004, system maintenance included raking the iron media in the treatment cells and periodic system checks over the course of the year. In 2003, Site personnel performed quarterly water level monitoring and semiannual analytical sample collection. In 2004, water level was monitored and groundwater sampled at most wells semiannually. In addition, the discharge line to South Walnut Creek and the flow measurement flume were cleaned and calibrated four times in 2003. In 2004, the flume was cleaned seven times and the meter was calibrated six times.

In January 2003, the discharge line from the flow meter became plugged. The line was partially cleared using a plumber's snake, but an obstruction in the line prevented the entire line from being cleared. The material removed from the discharge line appeared to be iron bacteria. The bacteria form where the reduced, iron-rich effluent is re-oxygenated as it passes through the flow meter flume. Line cleaning continues periodically, and the entire line was subsequently cleared.

In September 2003, crust formation caused the treatment cells to plug. Replacement of the zero-valent iron in both of the treatment cells was initiated. Both the iron and iron gravel/mixture were removed and replaced in both of the tanks. The lines were cleaned between the second vessel and the flow meter flume. The gravel layer was also replaced. After replacement was complete, normal operation of the system was resumed.

During the relatively brief periods in September 2003, when the treatment cells plugged and during media replacement, untreated water flowed into Pond B-3 in the South Walnut Creek drainage. Based on the influent data, the predominant contaminant was TCE. Samples were collected from Pond B-4, Pond B-4 influent, Pond B-5 (3 samples), and surface water location SW64492 to determine the impacts from releasing this water. Only the sample from the Pond B-4 influent had a detectable quantity of TCE at a concentration of 2.7 ug/L, below the surface water AL of 5 ug/L. In addition, acetone was detected at 4.1 ug/L in Pond B-5 and cis-1,2 dichloroethene was detected in Pond B-4 influent at a concentration of 3.2 ug/L. Chloroform, methylene chloride, naphthalene, vinyl chloride, and PCE were detected in one or more of the samples at concentrations less than 1 ug/L.

In May 2004, the upper portion of the media was changed again because of plugging. The plugging appears to have been caused by mixing problems and possibly because the level of media in the tanks was too high due to inaccuracies on the as-built drawings. The upper portion oxidized, which resulted in premature plugging of the tank. The entire upper layer of gravel and one foot of iron were removed from each of the tanks and replaced with new iron and gravel. The same mixture of 10 percent iron and 90 percent gravel was used, but was mixed with a

cement mixer to get a more homogeneous mixture. After the partial replacement of the beds, routine operation of the system was resumed.

In June 2004, evidence of partial plugging was again observed and water was routinely pumped from the west cell to the east cell once per week. This continued until December 2004 when a backhoe was used to remove a portion of the plugged iron. A hole about three feet in diameter was made in the plugged iron and gravel. The plugged media that was removed was disposed of. Some of material in the iron/gravel mixture appeared to be cemented together by precipitates; however, the plugged material appeared to be at the top of zero-valent iron bed. The plugged iron was approximately one foot thick. Samples were collected of a sludge found at the top of the tank and the plugged iron itself.

In May 2004, the treatment system samples were collected at the influent, from within the iron, and from the effluent in the wet tank to analyze precipitation and plugging process in the tank. Inverse modeling was performed using the United States Geological Survey geochemical modeling software, PHREEQC (Parkhurst and Appelo 1999). The PHREEQC equilibrium geochemical model was used to account for chemical concentration changes observed between the influent and effluent water in the west tank. Based on this modeling, it was determined that the relative abundance of these likely precipitates should be as follows (most abundant listed first).

- Fe (II) and Fe (III)-bearing minerals;
- Carbonate-bearing minerals, for example, calcite;
- Ca-bearing minerals, possibly Mg-rich, for example, Mg-calcite;
- Sulfide-bearing minerals, probably dominated by iron sulfides like mackinawite;
- Simple hydrous silica solids lacking Al, possibly as "amorphous silica";
- Mn oxyhydroxides as minor phases; and
- Ba and Sr carbonates or sulfates as trace phases.

In late 2004 to early 2005, additional work was performed to analyze plugging in the treatment system. Numerous aspects of the treatment system were evaluated including operation and maintenance, vessel configuration, and organic and inorganic processes within the tank. In November and December of 2004, both water samples and samples of solids from the west tank were collected for analysis. A rigorous and comprehensive analysis was performed on the plugged iron. Based on these results, the laboratory determined that the plugged iron likely consisted of the following:

- Ferrous iron metal - 74 percent;
- Calcium carbonate - 9.8 percent;
- Water - 9.0 percent;
- Silicon dioxide - 5.2 percent; and
- Organic carbon - 1.6 percent.

The ferrous iron is likely a mixture of unreacted zero-valent iron and ferrous iron minerals because it does not appear that analysis distinguished between the two.

Based on the tank evaluation, in addition to plugging by precipitation of iron minerals and calcium carbonate, it was determined that trapped gases and bacterial growth were also major factors. The gases evolved from the reactions with the iron and possibly from anaerobic bacteria. These gases were found to block the passage of water in the gravel and iron. It was found that gases trapped in the vessels could be alleviated by using an aluminum or steel bar to perforate the beds and this has since been adopted as a routine maintenance activity.

Laboratory testing was performed in December 2004 to determine whether it was feasible to treat the plugged iron with hydrochloric acid. Based on these tests, it appeared that acid treatment could be viable. It was later determined that it might also help alleviate bacterial problems. On May 23, 2005 twenty-four gallons of hydrochloric acid was added to the west tank and allowed to sit for eight days. After the acidic solution was removed and treated, the permeability of the treatment media greatly improved.

In addition to releasing trapped gases and acid treatment, a number of changes in system operation were made in early 2005 in response to plugging problems and other issues, these included:

- A more detailed operation and maintenance manual was prepared.
- Downspouts were installed on the influent stream coming into each tank to prevent excess exposure of influent water to air at the top of the tank in March 2005. This should reduce oxidation of the zero-valent iron.
- Additional efforts were made to keep the system isolated from outside air.

3.4 Conclusions

The East Trenches Plume Treatment System is operating properly and successfully. The effectiveness was evaluated by comparing the objectives stated in the Decision Document to the system performance. The objectives evaluated were:

1. Intercept and treat VOC-contaminated groundwater at the distal end of the East Trenches Plume. Evaluated as collection system effectiveness (Section 3.4.1).
2. Protect surface water and reduce the VOC-contaminant mass loading in surface water, to the extent practicable. Evaluated as treatment system effectiveness (Section 3.4.2).

In addition, operations and maintenance information based on approximately five years of operation is described in Section 3.3 and is provided to allow further evaluation of overall effectiveness of this type of system for specific applications at RFETS.

3.4.1 Collection System Effectiveness

The system is collecting VOC-contaminated groundwater as shown by the following:

- The influent to the treatment cells consistently contains elevated VOCs (Tables 10 and 11).
- Approximately 3.6 million gallons of water were collected and treated in 2003 and 2004, approximately 9 million gallons since system installation in 1999. Water discharged without treatment did not pass through the flume and was not measured or otherwise included in this total.

The volumetric flow rates might be somewhat inflated because of water backing up into the flow meter flume due to a clogged discharge line, especially in February 2003. These peak flow rates

do not appear to be associated with precipitation events. However, it is evident that the system is collecting significant quantities of groundwater.

The collection trench intercepts contaminated groundwater in the alluvium and colluvium before it reaches surface water. The East Trenches Plume collection trench was not designed to intercept deeper bedrock flow; however, the collection trench is cut into the bedrock and it likely collects limited flow from the upper bedrock surface. The subcropping Number One Sandstone was intercepted by the collection trench and the system collects groundwater transmitted by this unit. It is also collecting water from a highly permeable zone encountered at the western end of the plume.

Based on the estimates of groundwater flow in the East Trenches Plume PAM (DOE 1999b), the projected recovery from the trench was 5.3 gallons per minute. As shown on Figure 2, the captured flow often exceeds this flow rate. Even during 2003 when there were still impacts from the drought, the average flow rate for the year was 4.23 gallons per minute. Based on this, the collection system is operating as designed, and bypass is limited in extent.

Based on the downgradient wells, it appears that there is a relationship between groundwater downgradient of the collection trench and surface water. Although groundwater levels are influenced by pond levels, the ponds themselves are not considered the source of downgradient contaminants. Groundwater elevations in wells downgradient of the collection trench appear to be heavily influenced by the levels in the B-Ponds as opposed to water flow under or around the collection trench. As previously mentioned, when the ponds were excavated, a significant volume of water (about 5 gpm) was observed flowing into the southern side of excavation; however, the absence of contamination in this water indicates that its source is not from the East Trenches Plume. The water could be from bedrock flow from areas outside the plume, or it could be groundwater flow around the southern side of the B-1 dam because the dam goes all the way to bedrock. It should be noted that this location is a likely place to find contaminated groundwater if flow under the trench was occurring.

Water level data from wells and piezometers, together with the volume of water recovered in the collection system, indicate that the collection trench is collecting groundwater thought to be primarily from the upper hydrostratigraphic unit (UHSU). Based on the groundwater elevations in the trench piezometers, some groundwater pooling is occurring at the western end of the collection trench. Even with the pooling, water elevations within the collection trench are lower than water elevations in the surrounding area prior to system installation.

The downgradient plume is most likely a result of the residual groundwater plume cutoff by the collection trench and/or a result of residual soil contamination left by the plume from earlier periods of higher concentrations.

The hydraulic gradients and saturated thickness in this area of Well 23296 could cause flushing of the contaminants. Although there appears to be decreasing trend in this well since the trench was installed, there are not sufficient data to verify this trend at this time.

If there is a deeper path of migration under the trench, it is likely through the deeper bedrock that the trench was not intended to intercept. There is no discernable evidence that downgradient concentrations are increasing. Neither key downgradient well (23296 or 95199) demonstrated statistically significant (95% confidence level) increasing or decreasing trends based on seasonal Kendall trend testing (K-H 2004a). Well 23296 is downgradient of an area where underflow was thought to be likely and, although not statistically significant, appears to

show decreasing concentrations since the trench was installed. If significant underflow were occurring there should be a significant increase in concentrations in these wells, because the contaminant concentration of water collected by the trench is about 10 times higher and it is very close to the well.

3.4.2 Treatment System Effectiveness

As previously noted, plugging of the zero-valent iron reduced the effectiveness of the system to the point where effluent concentrations for methylene chloride, TCE, and PCE exceeded RFCA ground water and surface water standards in April and September. In addition, the effluent chloroform concentration was also above RFCA surface water standards in April and September. Samples collected in November 2003 demonstrate that the normal removal efficiency of the system was restored once the zero-valent iron was replaced. In November 2003, TCE at 5.7 ug/L and methylene chloride at 17 ug/L were greater than the RFCA Tier II Groundwater AL of 5 ug/L each. The improved performance continued through 2004. Other than methylene chloride, only one TCE concentration, of 6.36 ug/L, in May 2004 was above the RFCA Tier II groundwater AL of 5 ug/L. Based on the bench scale tests, the system was not expected to be effective at removing methylene chloride, which could be present as a treatment degradation product. As shown, the system is effective in removing the major contaminants present in this groundwater plume.

The treatment system is operating as designed and about 21,000 grams of VOCs are removed each year. The first change-out of the iron in the system was anticipated, although it occurred a little earlier than predicted, at 4 years rather than 5 years. Although subsequent modification have been necessary; the East Trenches Plume Treatment System was operational and did reasonable well in treating contaminated groundwater to specified system performance requirements in 2004.

3.5 Planned Activities

Additional steps are being taken to reduce plugging and provide better monitoring of the treatment cells. These steps include periodic removal of the upper gravel layer to reduce precipitates and plugging of the treatment cells if needed and visual monitoring of water levels in the vessels. More effort will also be made to keep the doors at the tops of the tanks closed.

Ongoing maintenance (that is, raking the iron filings, perforating the beds, and monitoring) will continue. In addition, periodic cleaning of the discharge line from the flow meter is necessary because of the buildup of iron bacteria. Sampling of the treatment system is expected to continue semiannually. Analytical results will be monitored to indicate when the iron needs to be replaced.

4.0 SOLAR PONDS PLUME TREATMENT SYSTEM

The SPP Treatment System was installed in 1999 pursuant to the Final SPP Decision Document, Major Modifications to the Final Proposed Interim Measures/Interim Remedial Action Decision Document for the Solar Evaporation Ponds Operable Unit 4, 1992 (SPP Decision Document) (DOE 1999c). System installation is documented in the Draft Solar Ponds Plume Completion Report (DOE 2000b – not finalized). The SPP Treatment System collects and treats low-level nitrate and uranium-contaminated groundwater from the Solar Ponds groundwater plume. Installation of the 1,100-foot long collection system and treatment cell containing wood chips and reactive iron was completed in 1999 (Figure 14). Treated water is discharged back

into the groundwater on the downgradient side of the treatment cells through a discharge gallery that was designed to overflow to the surface when the surrounding soil is saturated. This overflow discharges to the surface immediately downgradient of the treatment cell near North Walnut Creek.

The PMJM (a federally listed threatened species under the Endangered Species Act) is present at the optimal location for a flow-through treatment cell. Therefore, the treatment cell was located immediately adjacent to the collection trench and not 400 feet downgradient as originally planned. As a result, the collection trench for this system was required to hold approximately 11 feet of groundwater within a several-hundred-foot section of the collection trench to develop sufficient hydraulic head for the groundwater to flow into the treatment cell.

In October 2002, a solar-powered pump was installed within the collection trench to pump the collection trench water into the treatment cell and to maintain a lower level of groundwater within the collection trench. This allows the collection trench to operate as it was originally designed and eliminates the need for water to be stored within the collection trench. By maintaining a lower water level in the trench, more water will be collected and should reduce or prevent water from bypassing the treatment system. Installation of the solar-powered pump increases the amount of groundwater treated by the system.

In January 2005, Pond A-3 was emptied and used to store treated water from Pond A-4. Water in Pond A-4 had to be treated because of elevated Americium-241 levels, which did not originate from the Solar Ponds area. North Walnut Creek flow to Pond A-2 was diverted to Pond B-4. This continued through the spring of 2005. The flow of North Walnut Creek water to Ponds A-3 and A-4 has since been resumed.

4.1 Decision Document Objectives

In accordance with the SPP Decision Document (DOE 1999c), the objectives for this project were to:

1. Protect North Walnut Creek by reducing the mass loading of nitrate to surface water and ensure that surface water standards are met in the Creek.
2. Design and install a passive system to intercept and treat the SPP contaminated groundwater to remove nitrate.
3. Design and construct the reactive barrier system in a manner that minimizes the generation of low-level mixed waste and/or hazardous waste and protects the habitat of the PMJM, which was added to the Threatened Species List on May 18, 1998.
4. Design the reactive barrier system to allow easy access for operations and maintenance, and reactive media replacement or removal.
5. Evaluate effectiveness of reactive barrier system in removing nitrate.
6. Evaluate long-term effectiveness of the treatment system once it has been in operation for several years.

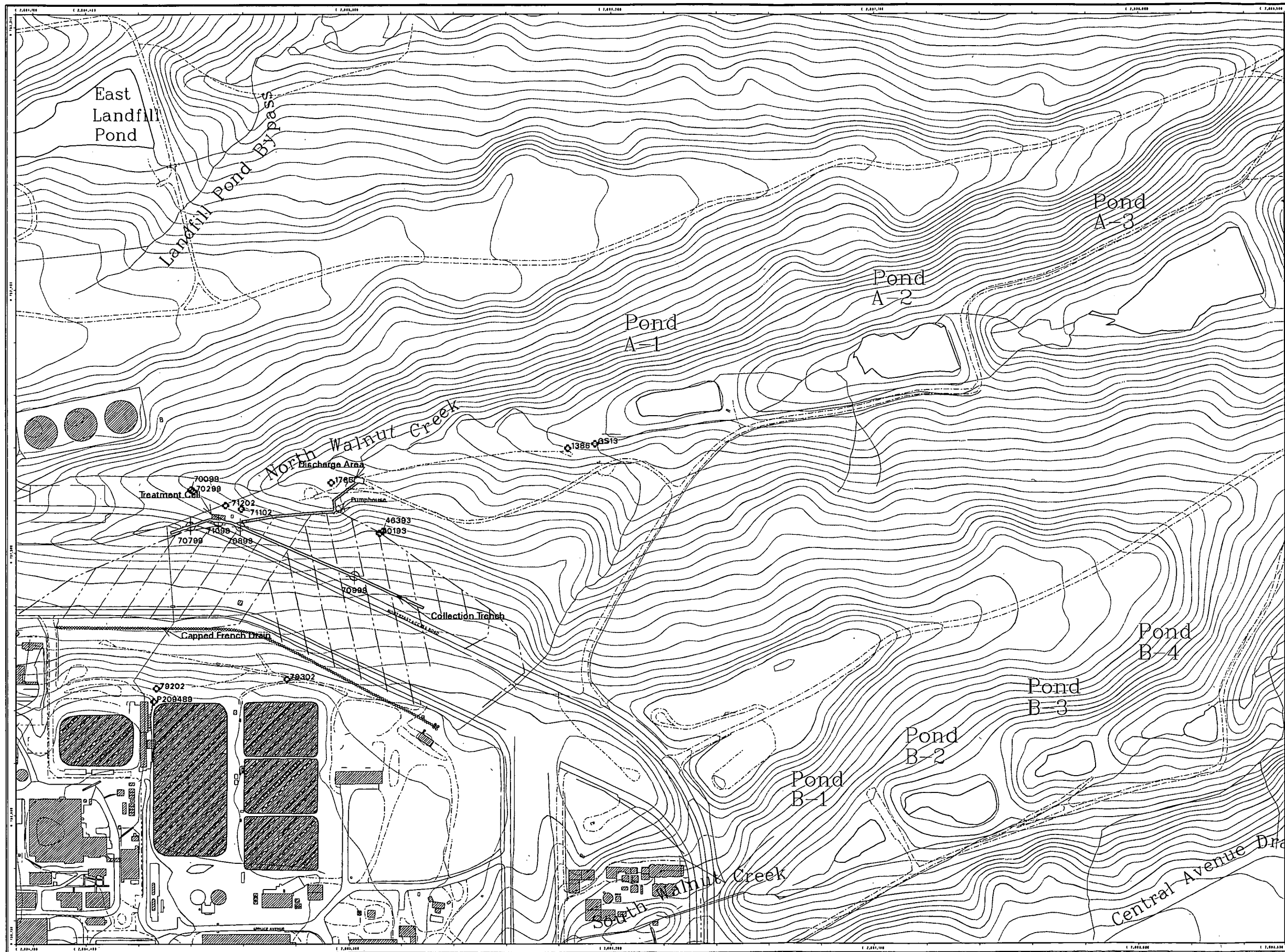
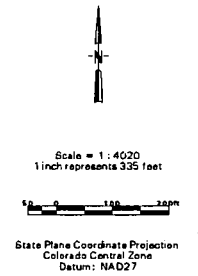


Figure 14
Solar Ponds Plume
Treatment System Locations

- EXPLANATION**
- Old Interceptor Trench System
 - French Drain
 - Treatment System Trench
 - Transmission Pipe
 - Discharge Gallery
 - In Trench Piezometer Location
 - Monitoring Well
 - Standard Map Features**
 - Buildings and other structures
 - Demolished buildings and Other Structures
 - Solar Evaporation Ponds (SEPs)
 - Lakes and ponds
 - Streams, ditches, or other drainage features
 - Fences and other barriers
 - Topographic Contour (5-Foot)
 - Paved roads
 - Dirt roads

DATA SOURCE BASE FEATURES:
 Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
 Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

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This report describes how Objectives 1, 5 and 6 are met. Objectives 2 through 4 were previously met during design and construction and are not discussed in this report. Section 5.5 of the SPP Decision Document contains Preliminary Decision Rules that are used in the effectiveness evaluation for Objectives 5 and 6 in this Report.

Preliminary decision rules for the project, as stated in the decision document, are as follows (DOE 1999c):

1. Steadily increasing water levels (in the collection trench piezometers) may be an indication that the media is plugged, requiring replacement.
2. If effluent concentrations exceed system performance objectives, then monthly or more frequent sampling will be performed until the cause is determined. If a corrective action is required, then monthly effluent sampling will continue for at least three months after a corrective action is implemented to ensure that the action is sufficient.
3. Based on preliminary calculations provided by CDPHE, the current stream standard will be achieved if effluent concentrations (of nitrate) are 500 milligrams per liter (mg/L). Effluent concentrations are expected to achieve this level. These preliminary calculations indicate that effluent concentrations must meet 50 mg/L to achieve surface water standards after 2009. Decision rules will be refined as performance monitoring trends are established and in anticipation of the decrease in the stream standard from 100 mg/L to 10 mg/L after 2009.
4. Groundwater monitoring will continue during and after the remedial action has been completed, as described in the IMP. Groundwater wells 1786 and 1386 currently monitor the drainage and will be, at a minimum, monitored for nitrate and uranium. An additional well cluster to the north of the barrier will be installed to provide additional data and performance monitoring. The frequency of sampling and analytical suites will be consistent with the IMP and will measure uranium and nitrate concentrations.
5. Performance monitoring in the North Walnut Creek Drainage will be implemented at station GS13 to monitor changes in surface water quality as a result of the selected remedy. This location was selected because it is immediately downstream of where the groundwater plume intersects the drainage. The loading to the stream will be evaluated to determine long-term system performance and will be reported on an annual basis. In accordance with the ALF, if the stream concentrations exceed stream standards, then an evaluation will be performed after consultation with the regulators.
6. If stream standards are met consistently at GS13 and if simple modeling techniques show that the stream standards would be met without treatment, based on the influent plume concentrations and flow rate, and the stream concentrations and flow rate that exist at that time, then treatment will be discontinued. This system is expected to continue operations until after Site closure when stream flow and concentrations have stabilized. The system will be abandoned in place as a flow-through system. System shutdown will be re-evaluated as part of the final Site Corrective Action Decision/Record of Decision (CAD/ROD).

4.2 Treatment Performance, Monitoring and Maintenance

System performance monitoring locations and frequency required by the SPP Decision Document are shown in Table 17. Although not required by the SPP Decision Document, sampling of the discharge gallery began in February 2000 to monitor the concentrations at this downgradient location. Water is often flowing at this location even when it is not at the treatment cell effluent.

Table 17. Monitoring Requirements for the SPP System

Task	Month 1-6	Months 7-12	Subsequent Years
Treatment System Influent – piezometer adjacent to treatment cell	Monthly	Quarterly	Semi-Annually
Treatment System Effluent – metering manhole	Monthly	Quarterly	Semi-Annually
Downgradient Surface Water Quality – GS13	Monthly	Quarterly	Semi-Annually
Hydraulic Head in Collection Trench – water level measurement	Monthly	Quarterly	Semi-Annually

The Preliminary Decision Rule 3 requires the effluent to have nitrate concentrations below 500 mg/L to protect surface water at the surface water standard of 100 mg/L. While the treatment objectives focused on removing nitrate contamination, the treatment system is also designed to remove uranium contamination. The surface water standard for total uranium is 10 pCi/L.

4.2.1 Treatment Performance

Most of the groundwater treated in the SPP Treatment System has been treated in the last two years. For the period January 1, 2003 through December 31, 2003, 340,000 gallons of water were treated. From January 1, 2004 to December 31, 2004, 230,000 gallons were treated. This is a significant increase over 2002 when only 5,600 gallons were treated. The sump was redeveloped in 2003 and 2004 and in addition, both years have been wetter. Daily average flow rates ranged from 0 to 6.72 gpm in 2003 and 0 to 2.52 gpm in 2004. The total volume of water treated by the SPP Treatment System between March 2000 and December 31, 2004 was approximately 1,027,000 gallons of which 55% was treated in the last two years. Table 18 provides the monthly influent and effluent data for 2003.

The treatment system is effectively removing nitrate to well below the performance requirement and is removing total uranium to below the surface water standard. The higher concentrations of nitrate and uranium at the discharge gallery apparently are caused by contaminated groundwater at higher concentrations than the treated effluent. Because the water is discharged through perforated piping, there is no way to determine the flow rate at this location.

Figures 15 and 16 show nitrate concentrations and uranium activities since the system was installed. Influent and discharge gallery nitrate concentrations appear to be increasing. Uranium activities and nitrate concentrations in the discharge gallery also appear to be increasing.

Table 18. SPP Treatment System 2003 Analytical Results

Collection Date	SPP Influent		SPP Effluent		SPP Discharge Gallery	
	Nitrate mg/L	Total Uranium pCi/l	Nitrate mg/L	Total Uranium pCi/l	Nitrate Mg/l	Total Uranium pCi/l
30-Jan-03	190	24.55	No flow	No flow	230	42.25
26-Feb-03	200	24.16	No flow	No flow	150	36.45
25-Mar-03	170	20.61	18	0.014	78	13.77
16-Apr-03	150	27.11	31	0.081	230	39.06
12-May-03	140	24.36	0.27	0.098	250	36.60
13-Jun-03	110	22.37	0	0.26	290	43.25
30-Jul-03	160	23.03	0.11	0.105	300	51.10
27-Aug-03	180	21.75	0.094	0.0209	140	41.93

Collection Date	SPP Influent		SPP Effluent		SPP Discharge Gallery	
	Nitrate mg/L	Total Uranium pCi/l	Nitrate mg/L	Total Uranium pCi/l	Nitrate Mg/l	Total Uranium pCi/l
29-Sep-03	170	24.25	No flow	No flow	290	44.21
29-Oct-03	200	26.45	No flow	No flow	320	47.62
24-Nov-03	180	26.88	0.46	0.0512	300	37.56
31-Dec-03	290	24.87	No flow	No flow	370	42.25
23-Jan-04	200	27.40	<0.05	0.08	380	66.71
26-Feb-04	210	24.918	<0.05	0.077	220	60.62
31-Mar-04	180	26.736	0.031	0.095	290	58.04
22-Apr-04	200	25.458	0.55	0.081	330	46.899
26-May-04	150	24.851	<0.050	0.059	330	60.03
25-Jun-04	160	23.87	0.024	0.024	350	39.48
26-Jul-04	120	22.405	0.026	0.036	360	54.04
30-Aug-04	130	24.176	0.032	0.027	330	23.123
27-Sep-04	150	24.393	0.028	0.07	420	14.848
27-Oct-04	75	24.305	0.2	0.095	310	41.395
30-Nov-04	150	25.743	no flow	no flow	350	167.34
30-Dec-04	150	28.827	0.14	0.108	380	45
26-Jan-05	210	27.273	2.3	0.257	460	80.28
28-Feb-05	220	26.72	0.13	0.165	470	50.99
28-Mar-05	240	23.584	1.3	0.19	690	55.352

SPP = Solar Ponds Plume
pCi/L = picocuries per liter

Figure 15. SPP Treatment System Nitrate Concentrations

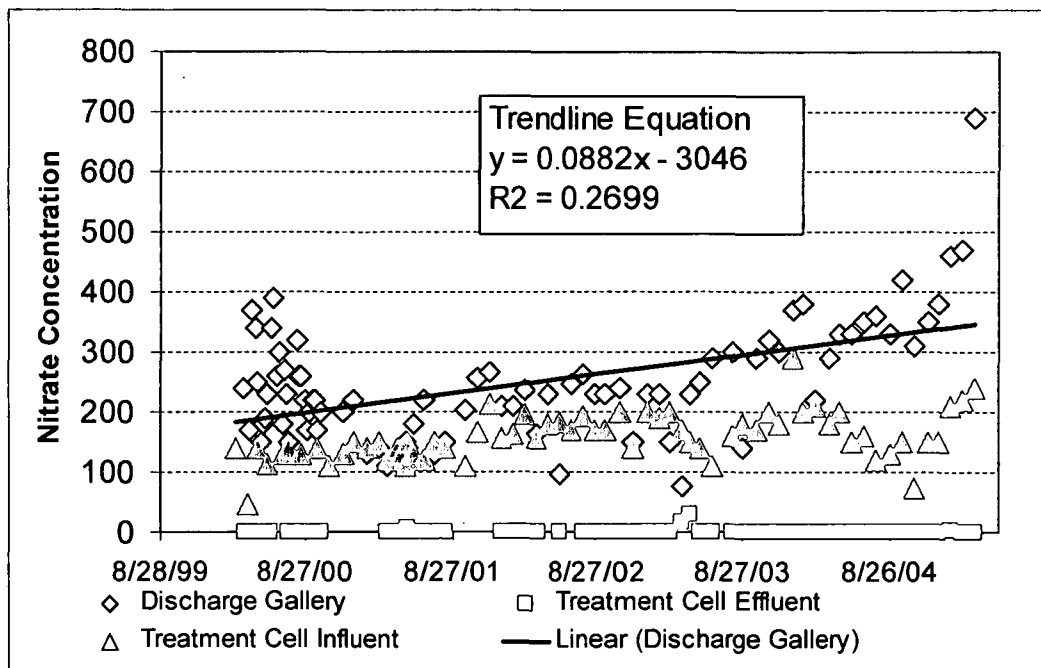
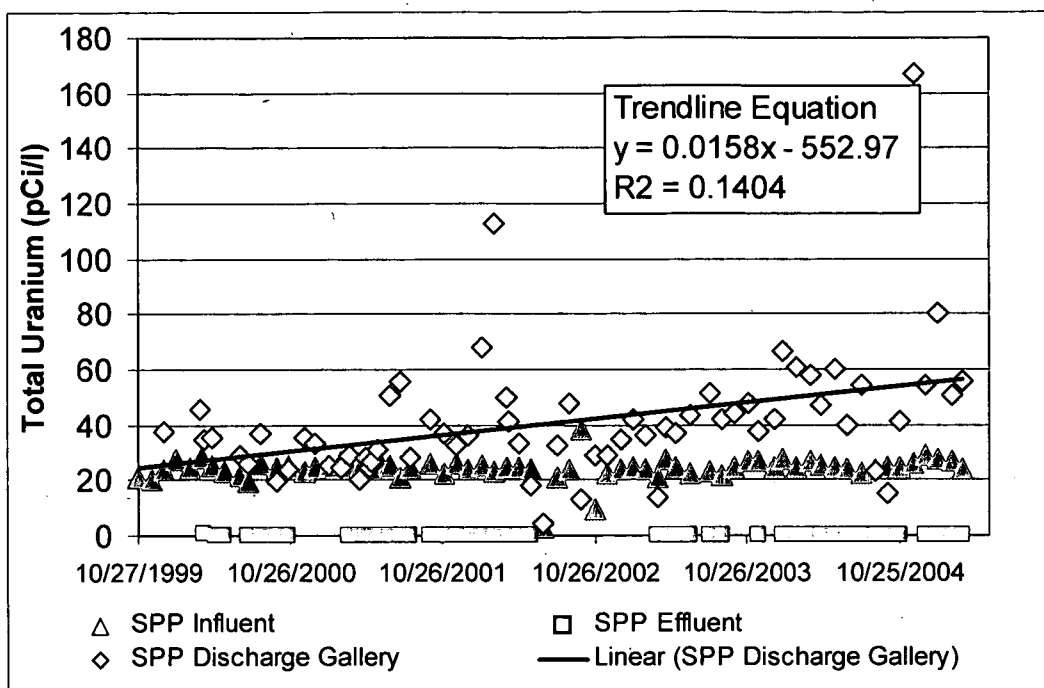


Figure 16. SPP Treatment System Uranium Activities



The approximate contaminant mass removed is shown in Table 19 and was calculated based on the total measured flow and the midpoint of the contaminant concentration range from Table 18. Previous years are included for comparison.

Table 19. Approximate Contaminant Mass Removed at SPP Treatment System

Year	Contaminant	Influent (ug/l)	Effluent (ug/l)	Removed conc. (ug/l)	Volume Treated (liters)	Total Mass Removed (g or uCi)
2004	Nitrate	142,500	287	142,213	870,800	123,839
	Total Uranium* pCi/l	25.62	0.066	25.55	870,800	22.25
2003	Nitrate	200,000	15,500	184,500	1,283,300	236,769
	Total Uranium* pCi/l	23.86	0.060	23.8	1,283,300	30.55
2002	Nitrate	170,000	245.00	169,755	21,200	3,599
	Total Uranium* pCi/l	20.79	0.12	20.67	21,200	0.4
2001	Nitrate	159,500	2,650	156,850	1,604,400	251,650
	Total Uranium* pCi/l	24.64	0.08	24.6	1,604,400	39.4
1999/ 2000	Nitrate	150,000	550	149,450	109,600	16,380
	Total Uranium* pCi/l	23.95	0.51	23.4	109,600	2.6

In the past, higher flow rates have not appeared to have an effect on removal efficiency for nitrates. However, with the very high flow rates seen after the March 2003 snowstorm, there did

appear to be a significant increase in nitrates in the effluent even though there was not an increase in the influent. The reason for this increase is not known, although likely factors are the residence time in the tank and possibly, there was fewer bacteria present in the tank during the winter months because of a lower influx of nutrients. Another contributing factor might have been that the cells were probably partially dewatered prior to the snowstorm because of low flow rates because of a plugged screen in the collection trench sump. Although the sump was redeveloped a few weeks before the snowstorm, there may not have been enough time for the microbial community in the cells to reestablish itself, resulting in increased nitrate concentrations in the effluent. Monitoring of the effluent continued through 2004 during which effluent concentrations were much lower. Based on 2004 data, it appears that the treatment cells are still viable and have not had significant reduction in removal efficiency.

4.2.2 Groundwater Monitoring

Pursuant to the SPP Decision Document, groundwater monitoring is conducted as described in the IMP. Wells 1786 and 1386 currently monitor uranium and nitrate concentrations in the downgradient groundwater.

4.2.2.1 Upgradient Water Quality

Well P209489 was previously used to monitor the upgradient water quality. This well was removed as part of the Solar Ponds remedial action and replaced with Well 79202. Results for Well 79202 are presented in Table 20. The concentration and activity levels are similar to past levels in Well P209489, about two times the levels in the influent. Well 79302 was also recently installed east of Well 79202. Although the uranium activities in Well 79302 are similar to those in Well 79202, the nitrate/nitrite concentrations are almost an order of magnitude higher.

Table 20. 2003/2004 SPP Upgradient Well Analytical Results

Well	Date	Nitrate/Nitrite (mg/L)	Uranium-233,-234 (pCi/l)	Uranium-235 (pCi/l)	Uranium-238 (pCi/l)
79202	1/30/03	360	40.3	4.6	38.4
	8/13/03	320	42	2.19	35.5
	12/11/03	480	49.2	6.35	40.4
79302	1/27/03	3210	61.8	2.53	40.4
	8/13/03	3200	71.7	2.25	45.3
	10/29/03	3000	80.2	2.27	48.4
	4/27/04	2840	83.7	5.48	50.2

Nitrate concentrations as high as those in Well 79302 have not been observed in the influent. It is likely that, due to dilution and dispersion, these concentrations will not be seen in the influent. However, based on these results, the influent concentration of nitrate to the treatment system may increase. Because the treatment system's removal efficiency does not appear to be impacted by higher nitrate concentrations as it is by higher flow rates, higher concentrations are likely to be removed to meet the Preliminary Decision Rule 3, 500 and 50 mg/L nitrate values. Based on performance to date, the treatment system will effectively treat these higher concentrations except, potentially, during periods of higher than average flow.

4.2.2.2 Downgradient Water Quality

Groundwater samples were collected and analyzed quarterly from the three downgradient wells and data are provided in Table 21. Piezometers (71102 and 71202) measure water levels and are not sampled. These wells were removed in 2005 for constructing a functional channel as

part of Site land configuration activities. Wells 70099 and 70299 are twinned wells in the colluvium and the bedrock, respectively. Nitrate concentrations immediately downgradient in Wells 70099 and 70299 are significantly lower than those observed in both the collection trench and the discharge gallery in 2003. Samples were not collected in 2004. As previously observed, the 2003 uranium activity in the colluvial well (Well 70099) exceeds background activities and is higher than elsewhere in the collection and treatment system. In addition, the uranium activity is much higher than that of the adjacent bedrock well, possibly indicating a pre-existing higher activity in the colluvium. Groundwater from Well 70099 was analyzed using Inductively Coupled Plasma/Mass Spectrometer (ICP/MS) for uranium isotopes, and the signature is consistent with naturally occurring uranium.

Table 21. SPP Downgradient Well Analytical Results

Well	Date	Nitrate/Nitrite (mg/L)	Uranium-233/234 (pCi/l)	Uranium-235 (pCi/l)	Uranium-238 (pCi/l)	Total Uranium (ug/l)
1386	01/16/03	0.054	7.39	0.262 J	6.73	-
	04/30/03	0.013 B	8.67	ND	6.91	ND
	05/07/03	-	13.1	0.585 J	10.7	-
	08/12/03	0.046 B	8.48	0.333 J	6.07	-
	10/14/03	0.21	-	-	-	17.5
	11/05/03	-	8.52	0.66 J	7.32	-
	06/08/04	ND	8.45	ND	6.72	28.6 BN
	11/04/04	ND	-	-	-	16.3
1786	1/9/03		36	1.64	25.1	
	1/30/03	326	32.9	2.78	25.7	
	2/25/03	341	34.2	1.77	24.4	
	3/26/03	270	33	2.75	25.4	
	4/22/03	310	18.3	0.908	11.8	87.5 B
	5/22/03*	-	29.2	2.96	22.7	
	6/22/03*	-	3.5	0.137	2.52	
	8/21/03	426	32.6	2.04	22.6	
	10/14/03	380	31	1.21	23.1	
	1/9/2004	504	36	1.64	25.1	72.6
	6/9/2004	275	30.7	1.63	24.9	
	9/28/2004	0.164	31.9	1.46	25	
70099	1/16/03	1.1	106	3.58	75.1	
	5/12/03	1.2	102	6.64	78.2	
	8/12/03	1.2	103	3.4	74.2	
	10/15/03*	1.3	78.8	3.28	58.7	
70299	1/16/03	0.044B	5.09	0.214	3.45	
	4/23/03	0.072	5.64	0.369	4.2	
	9/8/03	ND	6.09	0.319	4.27	
	10/15/03*	0.036B	4.82	0.261	2.77	

* = Uranium samples were filtered

- = Not sampled

B = Detected below required detection limit

BN = Estimated below required detection limit

ND = Not Detected

Well 1786 is located farther downgradient of the collection trench, just upgradient of the discharge gallery. Nitrate concentrations at this location ranged from 270 to 504 mg/L, which is higher than what is observed in the treatment system influent. Uranium activities in this area are

also consistently elevated. The source for this downgradient plume is believed to be from a past leak of higher uranium- and nitrate-contaminated groundwater from the pre-existing Interceptor Trench System (ITS) sump. Observations of this sump have shown that it was not watertight and historical data from this location have high nitrate levels in the water and sediment. The sediment sample collected from the sump in March 2003 had a nitrate concentration of 159 milligrams per kilogram (mg/kg), showing that the sump is no longer a significant source of contamination. (Note: for comparison, the Wildlife Refuge Worker Preliminary Remediation Goal for nitrate in subsurface soil is 2,044,000 mg/kg [DOE 2004c]).

Flow from upgradient areas, such as around Wells 1786 to the discharge gallery, is a likely explanation for higher activities in the discharge gallery than the treatment system effluent concentration. Although cleaner water is coming from the treatment system effluent, the flow rates have been low. Concentrations in the discharge gallery probably reflect upgradient residual contamination in the immediate area more than the treatment system discharge. These may take a long time to equilibrate with the waters from the discharge gallery. However, nitrate concentrations in Well 1786 are not a lot higher than the discharge gallery, so it does not appear that discharge gallery concentrations will increase much more, especially if flow through the treatment system is improved.

Wells 40193 and 46393 (Figure 14) are also upgradient of the discharge gallery. Although they are a little farther to the east, they probably have similar nitrate concentrations and uranium activities to the groundwater migrating into the discharge gallery. Well 46393 was sampled in December 1997 prior to the installation of the collection trench and had a nitrate concentration of 970 mg/L and total uranium isotopes of 45.52 pCi/L. Both of these wells were sampled in April 2003. The nitrate concentration in Well 46393 had dropped to 370 mg/L and total uranium activity had dropped to 27.68 pCi/L. Similar nitrate concentrations of 400 mg/L were found in Well 40193 although the total uranium isotopes were much higher at 185 pCi/L. The drop in concentration, especially in nitrates, is most likely because of its movement downgradient to areas like the discharge gallery. Nitrates are more mobile than VOCs and uranium. Although movement downgradient could have been facilitated by the ITS piping, the speed of its movement appears to be more consistent with groundwater movement alone because it has taken four to six years to appear.

Well 1386 continues to be monitored; however, it is farther downgradient and does not appear to have been influenced by the SPP. Nitrate/nitrite data from 1995 to 2004 is non-detectable or below 0.4 mg/L, except for one 3.5 mg/L value. This is significantly higher than the other data and it appears to be an outlier. During the same period, the total uranium ranged between 10.45 and 24.39 pCi/L and averaged approximately 16 pCi/L for filtered and unfiltered samples combined. This was higher than an upgradient well; however, ICP/MS analyses show that the uranium is natural, and not part of the SPP. Since startup of the treatment system in 1999, nitrate/nitrite concentrations remain below 0.33 mg/L and averaged 0.09 mg/L. Total uranium isotopes since startup are between 10.5 and 24.5 pCi/L. Because nitrate is more mobile than uranium, the low nitrate concentrations here appear to indicate that the Solar Pond plume has not impacted this area.

Water quality was measured at the SPP discharge gallery; surface water station GS13, located in North Walnut Creek immediately downgradient of the SPP; and downgradient Pond A-3, which accepts the water that passes through GS13. GS13 and Pond A-3 were monitored frequently to verify that concentrations at both locations were below the temporary modification stream standard for nitrate of 100 mg/L. Tables 22 and 23 provide summaries of these analytical data.

Table 22. 2003 SPP Summary of Downgradient Surface Water Locations

Date	SPP Discharge Gallery	GS13	Pond A-3	SPP Discharge Gallery	GS13
	Nitrate (mg/L)			Total Uranium (pCi/l) *	
1/30/2003	230	11	4.4	42.25	7.94
2/26/2003	150	20	4.2	36.45	10.72
3/25/2003	78	5.4	2.1	13.77	1.99
4/16/2003	230	9.6	8.9	39.06	5.16
5/12/2003	250	21	7.4	36.60	7.19
6/13/2003	290	10	8	43.25	3.91
7/30/2003	300	27	2.8	51.10	8.16
8/27/2003	140	42	0.72	41.93	11.11
9/29/2003	290	57	0.4	44.21	13.12
10/29/2003	320	56	0.68	47.62	17.41
11/24/2003	300	34	2.6	37.56	14.58
12/31/2003	370	37	2.4	42.25	13.12
Minimum	78	5.4	0.4	13.77	1.99
Maximum	370	57	8.9	51.10	17.41
Average	245.7	27.5	3.7	39.67	9.53

* = Uranium is not measured at Pond A-3

SPP = Solar Ponds Plume

Table 23. 2004 SPP Summary of Downgradient Surface Water Locations

Date	SPP Discharge Gallery	GS13	Pond A-3	SPP Discharge Gallery	GS13
	Nitrate (mg/L)			Total Uranium (pCi/l) *	
1/23/2004	380	32	2.5	66.71	12.88
2/26/2004	220	23	0.98	60.62	10.65
3/31/2004	290	36	3.8	58.04	11.71
4/22/2004	330	12	5.1	46.90	3.63
5/26/2004	330	16	7.1	60.03	4.14
6/25/2004	350	27	4.6	39.48	7.12
7/26/2004	360	26	3.6	54.04	7.81
8/30/2004	330	48	2.5	23.12	11.33
9/27/2004	420	66	2.3	14.85	12.96
10/27/2004	310	42	9.7	41.40	12.93
11/30/2004	350	30	11	167.34	9.935
12/30/2004	380	37	11	54.09	10.887
Minimum	220	12	0.98	14.85	3.63
Maximum	420	66	11	167.34	12.96
Average	337.5	32.9	5.3	57.22	9.66

* = Uranium is not measured at Pond A-3

SPP = Solar Ponds Plume

As stated in Decision Rule 3, the current stream standards are being met with the concentrations seen at the discharge gallery. As stated in Decision Rule 5, loading to the stream is evaluated in this document. Based on the average removal efficiency in 2003, the influent concentration of nitrate was reduced by an average of 95 percent below that expected if no treatment system was in place. This represents a significant decrease in loading to the stream. A healthy vegetation population has established around the discharge gallery, indicating that additional mass removal in the discharge gallery area is taking place through phytoremediation.

GS13, located in North Walnut Creek, is the performance monitoring location for the SPP Treatment System. In 2003, the nitrate concentrations were generally higher than in 2002. The State of Colorado compares the 85th percentile of water quality data for a given stream segment against the applicable stream standard. As previously mentioned, preliminary Decision Rule 3 requires the effluent to have nitrate concentrations below 500 mg/L to protect surface water at the surface water standard of 100 mg/L.

For 2002, the 85th percentile concentration of nitrate was 32.3 mg/L as compared to 46.9 for 2003 and 44.1 for 2004. In 2002, the nitrate concentration also increased. This was attributed to decreased flows in North Walnut Creek as a result of persistent drought conditions. In 2003 and 2004, there were continuing drought effects; however, it appears that the increases in 2003 and 2004 are primarily due to movement of the nitrate plume on the downgradient side of the groundwater collection trench.

The nitrate concentrations still remain well below the applicable surface water standard of 100 mg/L (DOE 1999c). At Pond A-3, located downstream of GS13, nitrate concentrations remained about the same as they were in 2002. The average nitrate concentration at Pond A-3 was 3.7 mg/L in 2003 and 5.3 mg/L in 2004. None of the values exceeded 10 mg/L in either 2003 or 2004. The concentrations are significantly lower in Pond A-3 than in GS13, probably due in part to dilution from downstream water sources and nitrate removal by algae and other plants in and near the Pond, resulting in some phytoremediation. Figure 17 shows the nitrate concentrations in the discharge gallery, Pond A-3 and the surface water location GS13.

As indicated in Table 22, Table 23, and Figure 18, uranium activities at GS13 were greater than 10 pCi/L for six months out of twelve in 2003 and seven out of twelve months in 2004; however, the average activity was below 10 pCi/L during both years. In addition, in 2004, sample results from the outfall of Pond A-4 (that is, GS11, the RFCA point of compliance [POC] for uranium), remained below 10 pCi/L throughout 2003 and 2004. Total uranium activities ranged from 1.8 to 4.2 pCi/L in 2003. Slightly lower values were observed in 2004 with total uranium isotopes ranging from 1.3 to 3.3 pCi/L.

GS13 nitrate concentrations are significantly lower than the discharge gallery indicating that phytoremediation is occurring in this area from the established plants at the discharge gallery, and that the higher flow volume in the stream dilutes the discharge gallery effluent.

Figure 17. Nitrate Concentrations in Solar Ponds Surface Water Locations

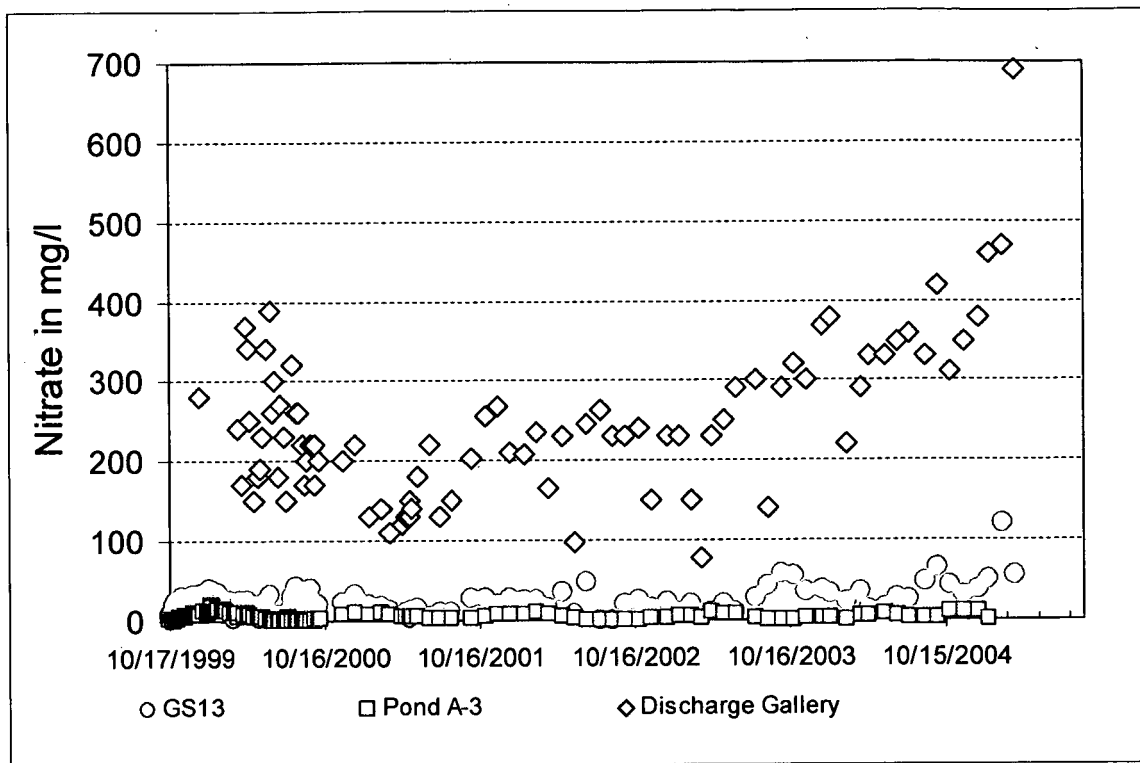
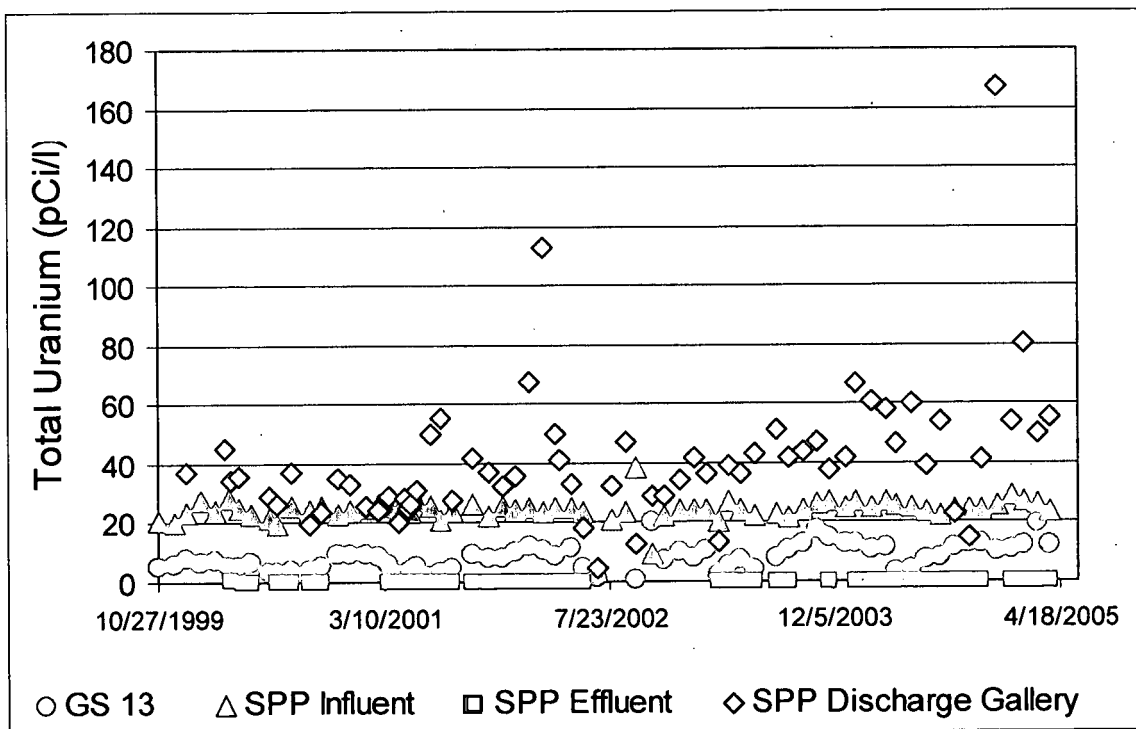


Figure 18. Uranium Activities in Solar Ponds Surface Water Locations



4.2.2.3 Water Levels

Water levels in the downgradient wells of the system were monitored monthly. These data are provided in Table 24, Table 25, and on Figure 19. The groundwater elevations in the downgradient wells were relatively stable during 2003. In 2004, the water elevations rose at all locations except 71202. Some surface features including a parking lot and roads were removed in this period, which could have increased infiltration. Other changes at the site, in addition to climatic changes, could have also increased infiltration. Groundwater elevations in the two newest piezometers (71102 and 71202) increased 15 to 18 feet since installation. This rise might be a result of the water levels equilibrating in the tight formations after well installation, or to a leak in the collection trench panels. The pump maintains water levels below the elevation of the potential leak, so water levels should drop with time in these piezometers water level changes are associated with a leaking panel.

Table 24. 2003 Groundwater Elevations in Downgradient Solar Ponds System Wells (Feet Above MSL)

Well	Jan 2003	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1786	5863.78	NM	NM	5865.76	NM	NM	5864.7	NM	NM	5864.21
70099	5876.91	NM	NM	5876.17	NM	NM	5877.39	NM	NM	5877.22
70299	5876.73	NM	NM	5876.76	NM	NM	5876.73	NM	NM	5876.48
71102	5869.37	5870.14	5870.24	5870.69	5871.39	5871.56	5871.38	5867.08	5870.27	5870.98
71202	5874.43	5875.45	5875.61	5875.86	5877.53	5877.94	5878.07	5869.21	5875.76	5877.33

NM = water elevation not measured

Table 25. 2004 Groundwater Elevations in Downgradient Solar Ponds System Wells (Feet Above MSL)

Well	Jan 2004	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Feb 2005	Mar 2005
1786	5865.88	5866.75	NM	NM	NM	5868.69	NM	NM	5870.52	NM	NM	5886.6
70099	5878.06	NM	NM	NM	5879.52	NM	5881.07	NM	NM	NM	NM	NM
70299	5875.07	NM	NM	NM	5879.75	NM	5880.16	NM	NM	NM	NM	NM
71102	5879.11	NM	5869.41	5869.24	5869.52	5869.55	5869.72	5869.81	5869.86	5869.92	5871.54	NM
71202	5876.85	NM	5874.56	5874.31	5874.87	5875.35	5875.62	5875.85	5875.99	5875.98	5876.16	NM

NM = water elevation not measured

Water levels within the collection trench are monitored at five piezometers at 70799, 70899, 70999, 71099, and Temp PZ. The inlet to the treatment cell is 5,885 feet above msl and the bottom of the collection trench is approximately 5,875 feet above msl. As shown on Figure 20, water levels in four of the piezometers fluctuate between 5,880 and 5,891 feet above msl. The fifth piezometer (70999), located at the higher, east end of the trench, has a minimum measurable water elevation of 5,900 feet. By design, water collected in this part of the trench drains to the west. This piezometer is generally dry when the water level of the other piezometers drops to 5,880 feet; however, during the last half of 2003 it was dry even though water levels were high at other locations.

Figure 19. SPP System Downgradient Well Water Elevations

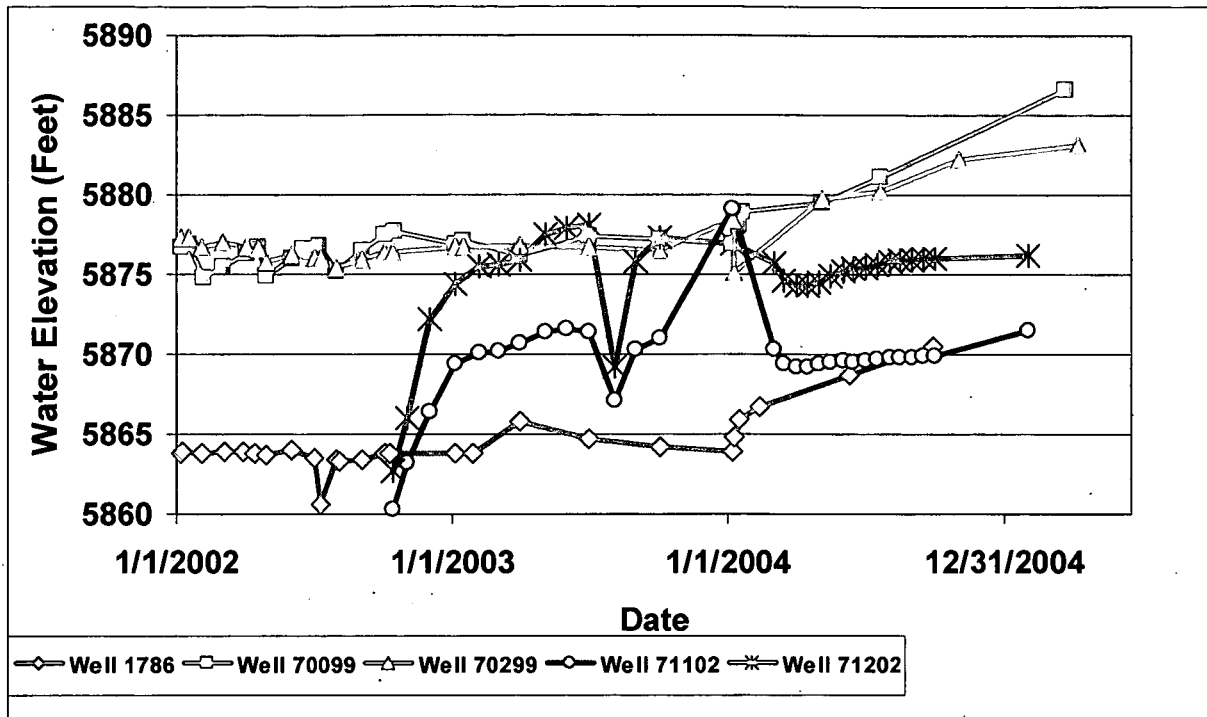
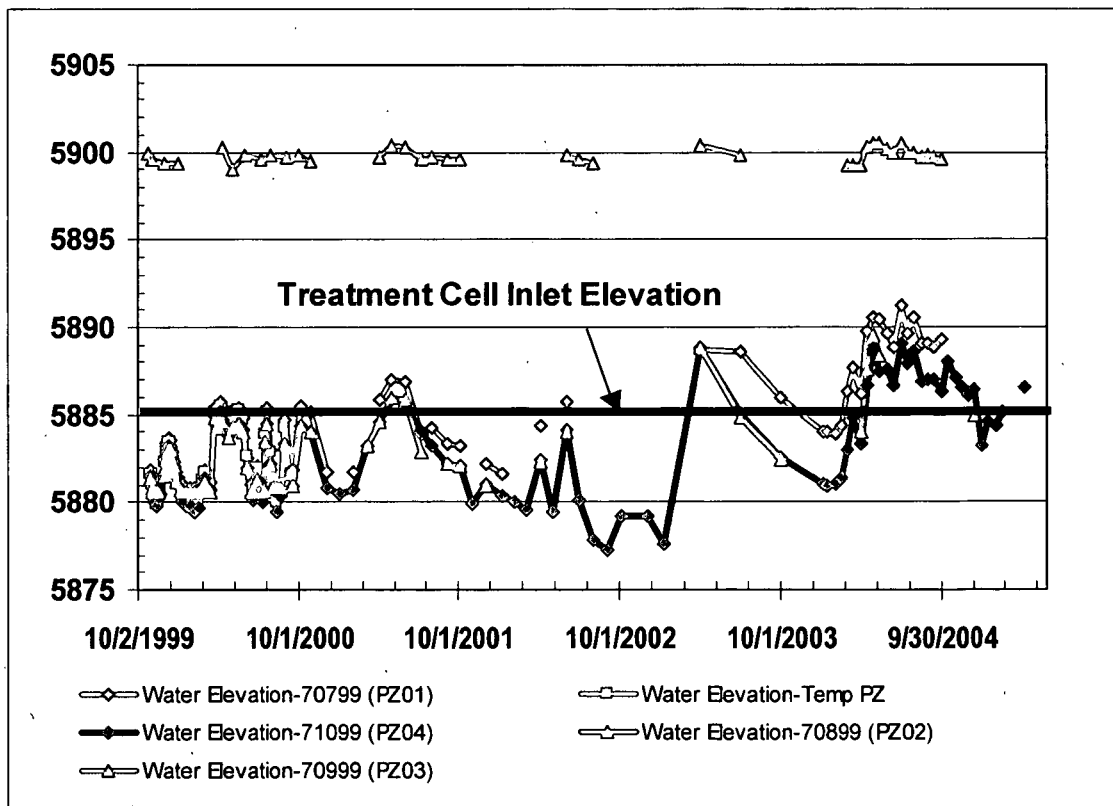


Figure 20. SPP Collection Trench Piezometer Water Levels



The pump installed in 2002 is set to keep water in the sump below an elevation of 5880 feet, which should result in similar water elevations in the piezometers near the sump (all but 70999). The ability to maintain this level is limited by the capacity of the pump. The pump capacity was exceeded after the heavy March snowstorm in 2003 and the water level rose in the trench. The water level continued to rise in the trench and remained elevated for some time, even with continued pump operation. Although the pump continued to operate and there was flow out of the treatment system, the elevated water levels in the trench indicated a partially plugged sump screen. The sump was redeveloped in 2004. Similar problems were observed in 2004. Some equipment and flow problems were identified and corrected in 2004 and 2005. Additional details are in Section 4.3.

There are significant differences in groundwater elevations between 70799 and the two nearby piezometers, 70899 and 71099 that were not observed in the past. One potential explanation is that the pump in the collection trench causes fluctuation of water levels within the collection trench. Depending on when the measurements are made, there can be a substantial amount of draw down when the pump is on, resulting in a lower groundwater elevation in 70799.

4.3 Operations and Maintenance

Routine maintenance for the Solar Ponds Plume Treatment System consists of water level monitoring, pump inspection, and sample collection. Because the iron is more dispersed within the treatment media, the media does not require raking or other routine maintenance. Based on vendor experience, it is expected that media replacement will be required 10 years after installation.

After the pump was installed in October 2002, initial flow rates were low, although in the past there has not been any flow in November. While flow was observed, the flow rate was too low to be measured. A drop off in flow rates beginning in late November 2002 was determined to be caused by the sump well screen becoming plugged with fine-grained materials. The sump was redeveloped in March 2003 and much of the fine material was removed. The fines recovered from the sump appear to be native material that collected in the trench over time and not the bentonite that was used in installation of both the collection trench and the sump. This indicates that clogging of the well screen was due to site conditions rather than improper sump design or installation. Redevelopment of the well screen in the sump was performed again in 2004. It is anticipated that redevelopment of the sump will not become routine; however, it is likely that it will have to be performed at least one more time.

In 2004 following sump redevelopment, it was determined that the pump had stopped operating and might have seized up; however, it did not appear the excess sediment had caused the pump to bind. The pump was removed and replaced with an identical model. In August 2004, the batteries overcharged and the acid boiled out. Identical replacement batteries were installed in September 2004. In December 2004, it was determined that the charge controller was also damaged, and so it was replaced. Although these malfunctions with the pump and charging system might be related, it cannot be confirmed which occurred first. These components appear to be working normally since replaced.

In May 2005, flow within the treatment system was impeded, causing water to back up into the collection trench. The cause was not readily apparent because flow through the system was still occurring. However, water elevation in the second treatment cell effluent was less than in the first treatment cell, indicating water was not flowing at an optimal rate through the second cell. The second cell, which contains zero-valent iron, is not essential to treatment because it was

designed as a polishing step to remove uranium, and the first cell removes both nitrate and uranium. Therefore, the second cell was bypassed. Water levels in the system decreased and the overall flow rate increased from an average of 0.3 gpm to approximately 1.5 gpm. This is the preferred mode of operation.

Prior to 2003, the flow meter flume occasionally backed up from debris plugging the effluent line, producing erroneous readings. During 2003, the treatment system flow meter flume was cleaned once and calibrated three times to prevent this from occurring. In 2004, flow meter flume was cleaned eight times and calibrated six times. Site staff performed regular water level monitoring and sample collection.

The operation of SPP Treatment System is currently being evaluated and other changes might be necessary to improve performance.

4.4 Conclusions

The SPP Treatment System is operating properly and successfully. The effectiveness was evaluated by comparing the objectives stated in the Decision Document to the system performance. The objectives evaluated in Sections 4.4.1 and 4.4.2 are:

1. Protect North Walnut Creek by reducing the mass loading of nitrate to surface water and ensure that surface water standards are met in the Creek.
2. Evaluate effectiveness of reactive barrier system in removing nitrate.
3. Evaluate long-term effectiveness of the treatment system once it has been in operation for several years.

The evaluation also includes a comparison to preliminary decision rules for the project that are relevant to the proper and successful operation of the system as described below.

1. Steadily increasing water levels (in the collection trench piezometers) may be an indication that the media is plugged, requiring replacement.

This has not occurred although at times there have been elevated levels in the trench partly because of lower flow rates through second treatment cell as described in Section 4.3.

2. If effluent concentrations exceed system performance objectives, then monthly or more frequent sampling will be performed until the cause is determined. If a corrective action is required, then monthly effluent sampling will continue for at least three months after a corrective action is implemented to ensure that the action is sufficient.

Effluent has not exceeded system performance objectives, as described for Objective 3.

3. Based on preliminary calculations provided by CDPHE, the current stream standard will be achieved if effluent concentrations are 500 mg/L. Effluent concentrations are expected to achieve this level. These preliminary calculations indicate that effluent concentrations must meet 50 mg/L to achieve surface water standards after 2009. Decision rules will be refined as performance monitoring trends are established and in anticipation of the decrease in the stream standard from 100 mg/L to 10 mg/L after 2009.

Effluent nitrate levels have been generally below 50 mg/L, and well below 500 mg/L. However, system effluent is not the only contributor to nitrate in the stream. Higher nitrate concentrations than in the influent are observed at the discharge gallery. While

concentrations at the measuring point in the stream, GS13, are below 100 mg/L, they are expected to remain above 10 mg/L unless action is taken to address the levels at the discharge gallery. Total uranium concentrations are also elevated at the discharge gallery, and the levels at GS13 are above the stream standard for about 50 percent of the 2003 samples. However, the average total uranium is still slightly below the stream standard.

4. Groundwater monitoring will continue during and after the remedial action has been completed, as described in the IMP. Groundwater wells 1786 and 1386 currently monitor the drainage and will be, at a minimum, monitored for nitrate and uranium unless replaced with alternative locations. An additional well cluster to the north of the barrier will be installed to provide additional data and performance monitoring. The frequency of sampling and analytical suites will be consistent with the IMP and will measure uranium and nitrate concentrations.

The location and frequency of monitoring is described in the IMP.

5. Performance monitoring in the North Walnut Creek Drainage will be implemented at station GS13 to monitor changes in surface water quality as a result of the selected remedy. This location was selected because it is immediately downstream of where the groundwater plume intersects the drainage. The loading to the stream will be evaluated to determine long-term system performance and will be reported on an annual basis. In accordance with the Action Level Framework, if the stream concentrations exceed stream standards, then an evaluation will be performed after consultation with the regulators.

See Rule 3.

6. If stream standards are being met consistently at GS13 and if simple modeling techniques show that the stream standards would be met without treatment, based on the influent plume concentrations and flow rate, and the stream concentrations and flow rate that exist at that time, then treatment will be discontinued. This system is expected to continue operations until after Site closure when stream flow and concentrations have stabilized. The system will be abandoned in place as a flow-through system. System shutdown will be re-evaluated as part of the final Site CAD/ROD.

It is not yet apparent that stream standards for nitrate and total uranium will be met consistently at GS13, especially after the expiration of the temporary modification for nitrate.

4.4.1 Collection System Effectiveness

Upgradient concentrations are not significantly reduced from levels observed prior to system installation. The system is collecting significant volumes of contaminated groundwater as designed, and the solar-powered pump improves the collection performance. Maintenance of the pump well screen to clean soil fines will continue. Groundwater that daylights at the discharge gallery is downgradient of the collection system and is not collected. Groundwater collection in the discharge gallery area was not part of the Decision Document.

Therefore, Objective 1 is being met.

4.4.2 Treatment System Effectiveness

The system is effectively reducing the mass loading to surface water. Approximately 113 kilograms of nitrate contamination was removed by the treatment system during 2003 and 77 kilograms in 2004, which is consistent with removal rates in previous years. Effluent concentrations meet RFCA surface water action levels and standards for total uranium and nitrate.

Based on the amount of contaminant reduction in 2004, it does not appear that the media is losing any treatment capacity, and the expected life is perhaps several more years before replacement unless flow through the system becomes too obstructed.

Therefore, Objectives 1, 5 and 6 are being met.

4.5 Planned Activities

The SPP Treatment System has shown improved performance in collecting groundwater containing nitrate and uranium from the SPP and the treatment cell continues to effectively treat the nitrate and uranium. The collection sump will most likely be redeveloped in the future. The removal efficiency of the treatment system has not yet diminished. Performance monitoring data show that the average concentration at GS13 for total uranium and nitrate is below 10 pCi/L and 100 mg/L, respectively. Based on system performance, a new Decision Rule is proposed to evaluate the need for continued operation of the system based on projected flow rates after closure at the current mass load to the stream. If evaluation of the system shows that stream standards are projected to continue to be met, then the system will not be needed.

System performance continues to be evaluated by monitoring water levels and collecting water quality samples. Because water levels within nearby wells remain stable, these are monitored quarterly. Currently water levels in the collection trench are being monitored using in situ transducers with data loggers. Inspection of the flow meter continues to be performed monthly and the flume is cleaned as needed. The treatment system influent, effluent, discharge gallery, and GS13 are currently sampled monthly to monitor system performance and to determine if there are impacts to surface water. Based on these results, sampling will change to quarterly.

5.0 OU 1 - 881 HILLSIDE GROUNDWATER TREATMENT SYSTEM

The OU 1 - 881 Hillside groundwater collection and treatment system was installed in 1992. It consisted of a 1,435-foot-long French drain and a separate upgradient collection well. The French drain was decommissioned in 2000. Data are no longer collected at this location.

As a result of declining contaminant concentrations at the collection well, the Final Major Modification to the OU 1 CAD/ROD, signed in January 2001 (DOE 2001), included continued extraction and treatment of groundwater from the collection well for an additional one-year period to verify this downward trend. In accordance with the terms of the Final Major Modification, water recovery and treatment from the collection well were terminated in April 2002, because of the continued decline in contaminant concentrations.

5.1 Project Activities and Status

The collection well continues to be sampled quarterly. The 2003 and 2004 VOC analytes that are above detection limits are provided in Table 26. Figure 21 shows the TCE concentrations in the collection well relative to time and the overall downward trend. TCE and other contaminants continued to remain below the RFCA Tier I Groundwater ALs throughout the year. Additional statistical analysis of the OU 1 Collection Well using Seasonal Kendall Trend Testing is presented in Appendix D of the annual RFCA groundwater monitoring report (K-H 2004a).

Table 26. OU 1 Collection Well Analytical Results for 2003 Sampling Events

Analyte	Concentration Range (ug/l)		RFCA Tier I Groundwater AL (ug/l)
	2003	2004	
Acetone	ND-3.9J	ND-6.7J	365,000
2-Butanone	ND	ND-2.5J	2190000
Carbon Tetrachloride	0.31J –13.6	ND-1.2	500
Chloroform	0.9 J- 2.6	2.39-5.1	10,000
Cis-1,2-Dichloroethene	ND-1.38	ND-4.7	7000 ¹
1,1-Dichloroethene	7.24 - 16	4.67-11	700
Methylene Chloride	ND-1.2	ND	500
Tetrachloroethene	ND – 54.9	38.4-49.1	500
Toluene	ND	ND-0.45JB	100000
1,1,1-Trichloroethane	ND-2.3	ND-1.6	20,000
Trichloroethene	214D – 363D	257D-415D	500

¹ = Action level for total 1,2-dichloroethene

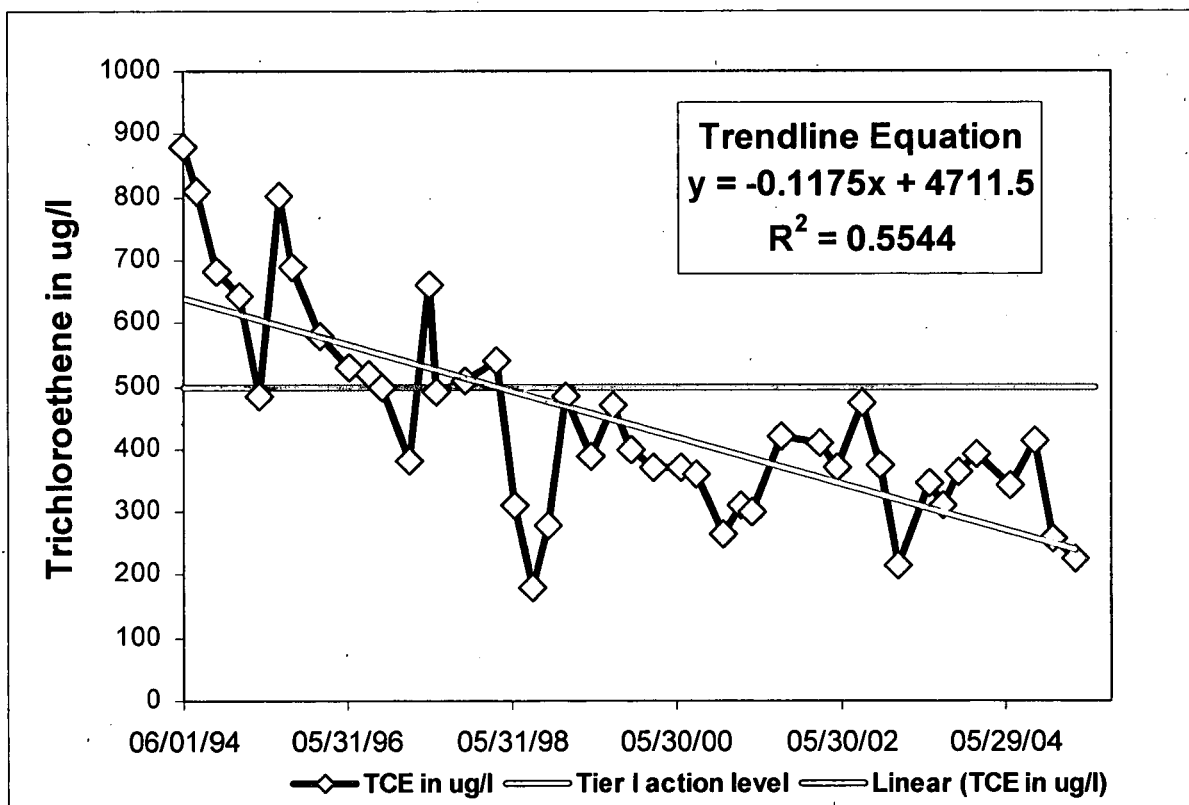
B= Detected in laboratory blank

D = Diluted

J = Detected at concentrations below required detection limit

ND = Not Detected

Figure 21. TCE Concentrations in the OU1 Collection Well



6.0 OU 7 - PRESENT LANDFILL PASSIVE SEEP INTERCEPTION AND TREATMENT SYSTEM

Groundwater contaminated with low concentrations of vinyl chloride and benzene discharges at a seep at the east end of the Present Landfill (OU 7). These contaminants are periodically above RFCA Surface Water ALs.

The passive seep interception and treatment system operated between October 1998 and February 2005. The water was collected in a settling basin, flowed through a pipe, down a set of stepped flagstones, and then over a six-foot-long bed of gravel before discharging into the East Landfill Pond. Flow was measured at the point of discharge. In accordance with the PAM for the OU 7 Passive Seep Interception and Treatment System (DOE 1998), water quality samples were collected from the treatment system discharge endpoint (SW00196), defined as the point six feet downstream from the last aeration step. Water released from the treatment system was collected in the East Landfill Pond, which was periodically pumped into Pond A-3 in North Walnut Creek. All water in North Walnut Creek passes through two RFCA POCs before it is discharged from the RFETS. The system was removed in early February 2005, and a new system was installed as described in the present landfill accelerated action construction certification report (K-H 2005).

6.1 Volume of Seep Water Treated

The total volume of seep flow measured and treated in 2003 was 1,143,000 gallons. In 2004, approximately 1,020,000 gallons were treated. When the system was shut down in February 2005, a total of 4,990,000 gallons of water had been treated. The volume treated by month is shown in Tables 27 and 28.

Table 27. Volume of Water Treated in the Present Landfill Passive Seep Interception and Treatment System During 2003

Month	Volume (gallons)
January	17,709
February	32,805
March	96,157
April	110,942
May	161,117
June	157,210
July	143,699
August	126,632
September	90,877
October	75,621
November	67,635
December	62,685

Table 28. Volume of Water Treated in the Present Landfill Passive Seep Interception and Treatment System During 2004

Month	Volume (gallons)
January	56,246
February	33,408
March	59,371
April	63,072
May	83,923
June	86,400
July	101,333
August	127,224
September	114,912
October	102,672
November	99,360
December	89,280

6.2 Treatment Effectiveness

Samples are collected and analyzed semiannually, in June and December. Sampling requirements are based on the Performance Evaluation Report (K-H 2000) and the Sampling and Analysis Plan (SAP) for the OU 7 Passive Aeration System (K-H 2001a). Analytical results are compared to RFCA Surface Water ALs to assess treatment system performance.

In accordance with the SAP, only VOC samples are currently collected and analyzed. All parameters analyzed in 2003 and 2004 were within RFCA standards, except for benzene. The benzene concentration ranged between not detected to 2.5 ug/L for all sampling events. The RFCA standard for Segment 4 is 1.2 ug/L. The other standards are shown in Table 29.

Table 29. Present Landfill Treatment System Water Analytes and Performance Standards

VOC Analytes	RFCA Surface Water Standard (ug/l)
Cis-1,2-Dichloroethene	70
Benzene	1.2
Chloromethane	5.7
Ethylbenzene	700
Methylene Chloride	4.7
Tetrachloroethene	0.8
Toluene	1,000
Trichloroethene	2.7
Vinyl Chloride	2
Xylene (Total)	10,000

RFCA values are based on RFCA Attachment 5, Table 1, Surface Water Action Levels & Standards for Segment 4, May 28, 2003.

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The SAP states that if a RFCA standard is exceeded in the semiannual monitoring, then a sample will be collected and analyzed the month following receipt of validated data. Preliminary data are received from the analytical laboratory within a month of sampling and validated results are received one month later. A sample taken in December 2002 was 1.6 ug/L and a follow-up sample was taken in January of 1.3 ug/L. Monthly samples continued after that; however, in 2004 construction activities limited access to the system and some monthly samples were not taken. All samples were just slightly over the 1-ug/L limit except in May 2003, March 2004 and April 2004. The results are shown in Table 30 for the period June 2000 through January 2005.

The water discharging from the Present Landfill Passive Seep Interception and Treatment System meets all RFCA Surface Water ALs, except for benzene. As stated in the RFCA Action Level Framework (ALF), the Segment 5 temporary modification to the stream standard for benzene is 5 ug/L, and the Segment 4 stream standard is 1 ug/L (the RFCA AL is applied as a standard in Segment 4). The temporary modification is in place until December 31, 2009. While the East Landfill Pond is located in Segment 4, water from the pond is transferred about once a year to the A-Series Ponds in Segment 5. Benzene is not an analyte of interest at the POCs at Pond A-4 or Walnut Creek and Indiana Street.

Table 30. Benzene Concentrations in Present Landfill Treatment System Effluent

Month	Benzene Concentration (ug/l)
June 2000	1
July 2000	1 (special sample)
December 2000	2
March 2001	1
June 2001	2 (duplicate sample concentration was 1 ug/L)
September 2001	1.4
December 2001	0.3 J
June 2002	0.94 J
December 2002	1.6
January 2003	1.3
February 2003	1
March 2003	1.2
April 2003	1.5
May 2003	0.99
June 2003	1.3
July 2003	1.7
August 2003	1.3
September 2003	1.5
October 2003	1.6
November 2003	2.1
December 2003	1.6
January 2004	1.6
February 2004	1.7
March 2004	ND
April 2004	0.33
June 2004	1.4

Month	Benzene Concentration (ug/l)
July 2004	1.4
August 2004	2.5
November 2004	1.9
December 2004	1.8
January 2005	1.3

J = Estimated below detection limit

ND = Not detected

The results for September 2001 through January 2005 were reported to tenths or hundredths of a microgram due to differences in protocols and reporting between different laboratories.

Although most of the samples for benzene were above 1 ug/L in both 2003 and 2004, it is not apparent if this represents an increase because concentrations are so close to the detection limit for benzene. There does not appear to be a clear relationship between the flow rate or total flow and the benzene concentration. It is likely the influent concentration to the system is the biggest factor affecting the concentration in the effluent.

6.3 Conclusions and Planned Changes

Monitoring will be discontinued under the PAM (DOE 1998) because the system has been removed and replaced as described in the present landfill accelerated action construction certification report (K-H 2005). The new system captures water from the old seep plus water from the strip drainage system, including flow from the groundwater interception system. The seep treatment system consists of a series of concrete steps. Water is passively aerated as it flows over the steps. This is similar to the previous system and replicates the natural treatment processes that occur in creeks and streams through aeration.

7.0 PU&D YARD PLUME TREATABILITY STUDY

A plume of VOC-contaminated groundwater originated from a contaminant source located in the PU&D Yard at RFETS. Investigation results indicate that subsurface VOC contamination was present in only a few locations and the primary contaminant is PCE (K-H 2001b). A treatability study was conducted to evaluate the effectiveness of HRC[®] for enhancing biodegradation of the VOCs in the groundwater and soil at the PU&D Yard Plume (K-H 2001b 2001c). HRC[®] is a proprietary, environmentally safe, food quality, polylactate ester formulated for slow release of lactic acid upon hydration.

The HRC[®] stimulated rapid degradation of chlorinated VOCs found in groundwater and soil at this location by making low concentrations of hydrogen available to the resident microbes to use for dechlorination. The HRC[®] was a one-time application that, according to the manufacturer, Regensis, was expected to stimulate contaminant degradation at the project site for approximately one and a half years. However, because some of the HRC[®] was inserted above the water table and the water table fluctuated considerably, it appears that additional degradation of contaminants within the vadose zone has continued to occur for more than four years, including 2003 and 2004, and will likely continue to occur for an unknown duration.

7.1 Project Activities

The treatability study is located within the source area and area of highest groundwater contamination within the PU&D Yard Plume (Figures 22 and 23). A monitoring well (30900) was installed in this area immediately adjacent to Borehole 17497, where the highest concentrations of VOCs in soils were detected. An additional monitoring well (Well 31001) was installed slightly downgradient of the source area in January 2001 as part of this study. Baseline groundwater samples were collected from these wells prior to insertion of the HRC®.

Beginning in February 2001, 16 material insertion points (MIPs) were used to place over 800 pounds of HRC® into the subsurface within a 10-foot by 6-foot area within the source area of the plume (Figure 23). The initial grid consisted of nine points. Additional Geoprobe™ boreholes used as MIPs were spaced between these initial locations, biased to the upgradient part of the source area. HRC® insertion was completed on March 1, 2001. Subsurface conditions were allowed to stabilize for two months before monthly sampling was initiated on April 30, 2001.

7.2 Treatment Effectiveness

Results from the initial baseline samples and the monthly and quarterly sampling events through 2005 are reported in Table 31. Earlier samples from the pre-existing monitoring well (Well 30900) and the groundwater sample from MIPs are also included for completeness. Concentrations of PCE, TCE, and cis-1,2-dichloroethene in the source area well (Well 30900) increased after insertion of the HRC®, then decreased (Figures 24). This effect was also observed in the downgradient well (Figure 25). According to Regeneration, 70 to 80 percent of project sites show an initial increase in VOC concentrations before a downward trend is observed. TCE and cis-1, 2-dichloroethene are common degradation products of PCE.

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Figure 22
PU&D Yard
Groundwater VOC Plume
Project Area

- EXPLANATION**
- PU&D Yard Monitoring Well
 - Groundwater Monitor Well
 - UHSU Surficial Material
 - Groundwater Monitor Well
 - UHSU Bedrock
 - Groundwater Monitor Well
 - UHSU Bedrock
 - Borehole Locations
 - × Abandoned Monitor Well
 - Composite VOC Groundwater Plume (concentration equal to MCL)
 - ▨ PU&D Yard IHSS

- Standard Map Features**
- Buildings and other structures
 - Landfill Pond
 - Streams, ditches, or other drainage features
 - Fences and other barriers
 - Topographic Contour (5-Foot)
 - Paved roads
 - Dirt roads

NOTE:
 Source of GIS data available upon request.



Scale = 1 : 2570
 1 inch represents approximately 214 feet



State Plane Coordinate Projection
 Colorado Central Zone
 Datum: NAD27

U.S. Department of Energy
 Rocky Flats Environmental Technology Site

GIS Dept. 303-866-7707

Prepared by:



CH2MHILL
 Communications Group

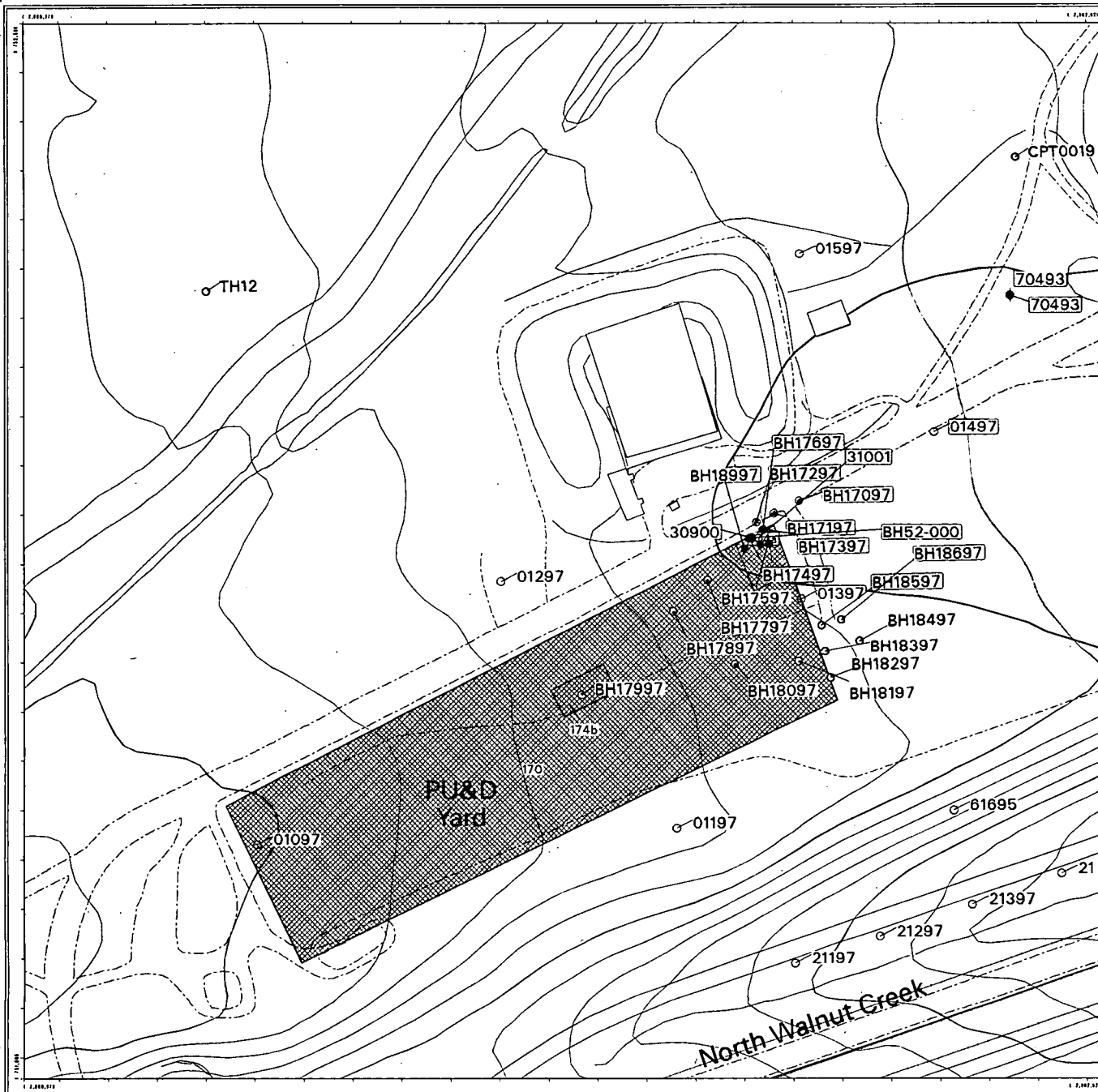
Prepared for:



ROCKY FLATS

March 27, 2003

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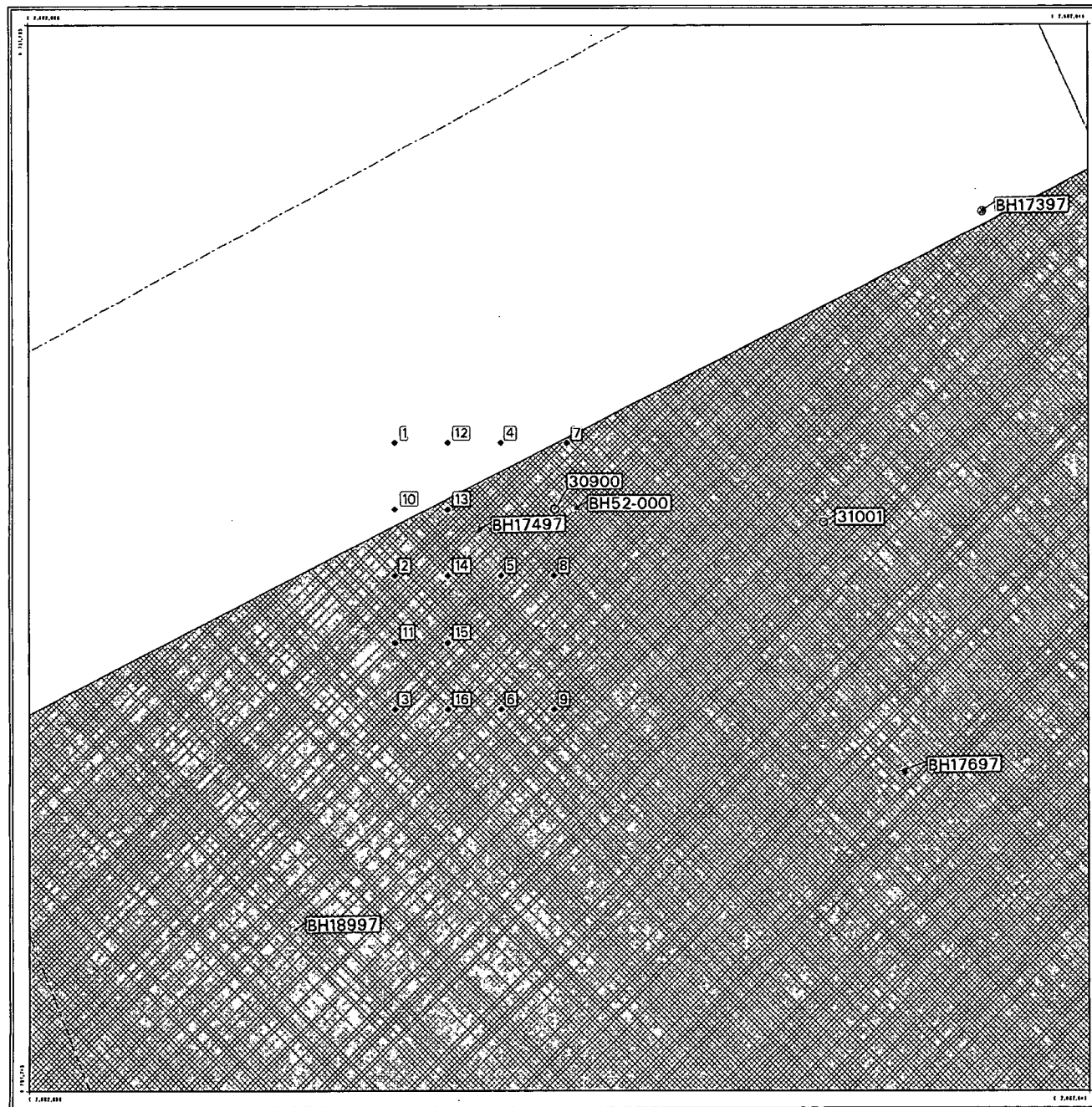


Figure 23
PU&D Yard
Groundwater VOC Plume
Material Insertion Point Configuration

EXPLANATION

- PU&D Yard Monitoring Well
- Groundwater Monitor Well
- UHSU Surficial Material
- Groundwater Monitor Well
- UHSU Bedrock
- Groundwater Monitor Well
- UHSU Bedrock
- Borehole Locations
- × Abandoned Monitor Well
- ◆ Material Insertion Point
- Composite VOC Groundwater Plume (concentration equal to MCL)
- ▨ PU&D Yard IHSS

Standard Map Features

- Buildings and other structures
- Land Fill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Topographic Contour (5-Foot)
- Paved roads
- Dirt roads

NOTES:
 Source of GIS data available upon request.



Scale = 1 : 70
 1 inch represents approximately 6 feet



State Plane Coordinate Projection
 Colorado Central Zone
 Datum: NAD27

U.S. Department of Energy
 Rocky Flats Environmental Technology Site

CH&M Dept. 903-956-7707

Prepared by:



Prepared for:



March 27, 2003

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Figure 24. PCE and Degradation Products Concentration versus Time in Well 30900

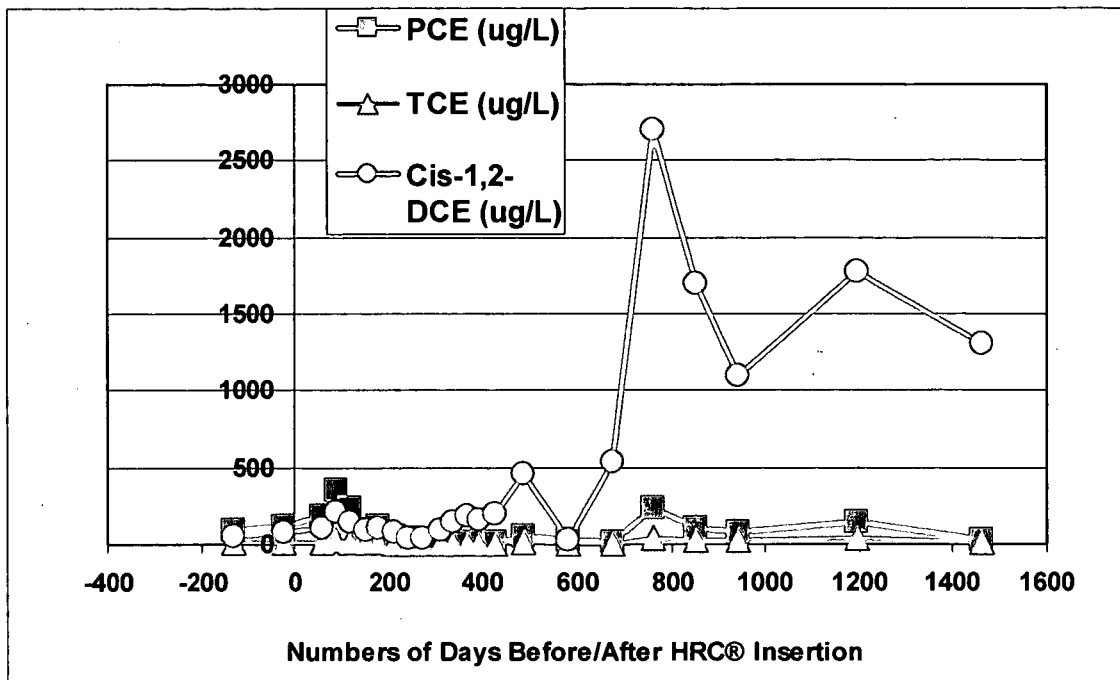


Figure 25. PCE and Degradation Products Concentration versus Time in Well 31001

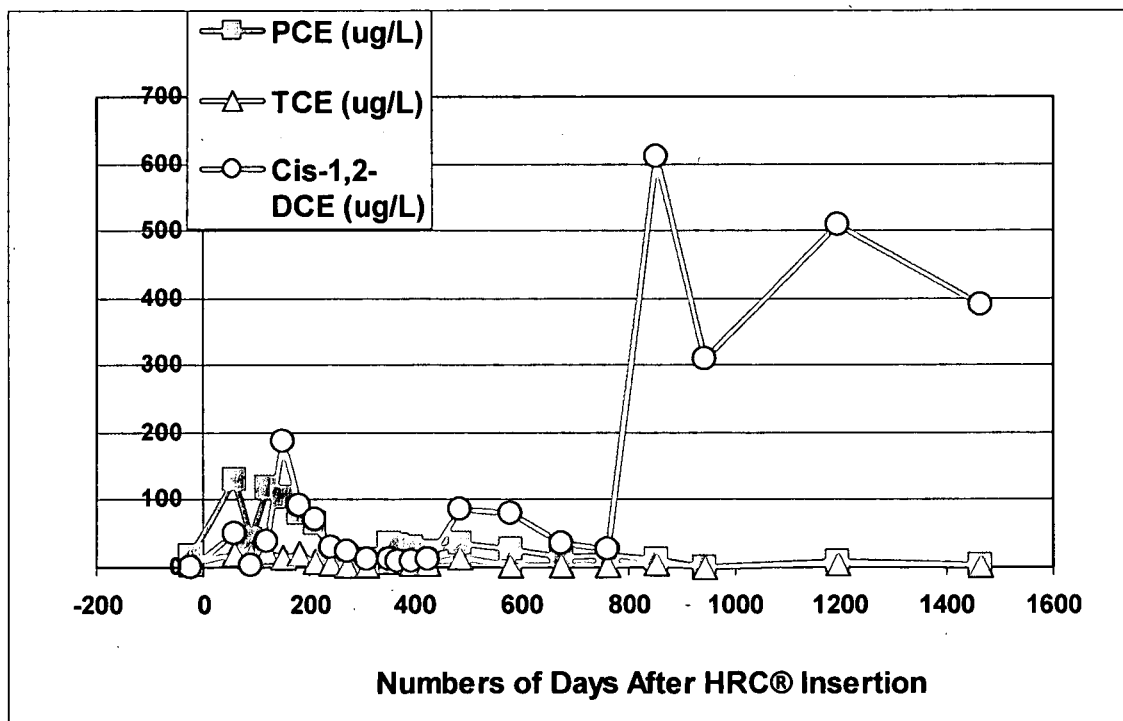


Table 31. Treatability Study Results (ug/l)

Location	Sample Date	Tetrachloro-ethene	Trichloro-ethene	Cis-1,2 Dichloro-ethene	Trans-1,2, Dichloro-ethene	1,1-Dichloro-ethene	Vinyl Chloride	Ethene
MIP3	2/20/01	4.9	ND	ND	ND	ND	ND	-
30900	10/21/00	96	7.4	53.1	ND	ND	ND	-
	2/7/01	120	7	78	0.5	0.5	ND	-
	4/30/01	180	11	110	0.1	0.4	ND	-
	5/30/01	350	23	210	ND	ND	ND	-
	6/27/01	240	15	140	0.2	0.5	ND	2
	7/31/01	93.6	10.6	91.4	0.19	0.31	0.21	ND
	8/28/01	116	15	100	ND	0.39	ND	ND
	10/1/01	50	5	77	ND	ND	ND	ND
	10/31/01	34	3.1	36	ND	ND	ND	ND
	11/29/01	30	3.6	45	ND	0.28	ND	ND
	1/7/02	18.5	2.92	88.6	0.212J	ND	ND	ND
	2/18/02	9.8	1.9	140	ND	0.38	ND	ND
	3/4/02	8.25	1.37	188	0.568J	0.51J	ND	ND
	4/1/02	15	2.7	160	ND	0.42	ND	ND
	5/2/02	7.5	1.6	200	ND	0.45	ND	ND
	7/1/02	46	9	460	0.58	1.5	ND	ND
	10/3/02	23	6.1	31	ND	1	ND	ND
	1/7/03	7	0.96	540	0.87	1.1	ND	3.43
	4/1/03	230	42	2700	1.1 J	5.4	ND	5.20
	7/1/03	110	31	1700	1.5 J	2.6	ND	-
	10/2/03	77	20	1100	ND	2.2	ND	-
	6/8/04	141	41.4	1780	ND	ND	ND	-
	3/3/05	31	9.8	1300	0.88 J	ND	ND	-
31001	2/7/01	18	5.5	1.2	ND	2.6	ND	-
	4/30/01	130	20	52	0.1	4	ND	-
	5/30/01	41	18	4	ND	ND	ND	-
	6/27/01	120	25	38	ND	1	ND	ND
	7/31/01	105	16.3	189	0.13	1.49	0.12	ND
	8/29/01	81	22	93	ND	ND	ND	ND
	10/1/01	67	7.7	71	ND	0.6	ND	ND
	11/1/01	18	4.8	30	ND	0.65	ND	ND
	11/30/01	15	3.7	24	ND	0.47	ND	ND
	1/07/02	12	3.78	12.1	ND	0.88	ND	ND
	2/18/02	37	9.4	13	ND	3.3	ND	ND
	3/4/02	34	9.23	9.27	ND	1.67	ND	ND
	4/1/02	30	6.7	10	ND	2.6	ND	ND
	5/2/02	25	6.6	12	ND	2.3	ND	ND
	7/1/02	35	16	85	ND	2.2	ND	ND
	10/3/02	27	2.4	79	ND	ND	ND	ND
	1/7/03	16	4.2	36	ND	1.7	ND	ND
	4/1/03	17	1.5	26	ND	0.25 J	ND	ND
	7/1/03	12	4.8	610	ND	2.3 J	ND	ND
	10/2/03	1.1	0.67 J	310	0.26 J	1.6	0.79 J	ND
	6/8/04	10.2	5.46	509	ND	ND	ND	-
	3/3/05	2.4	1.7	390	0.36 J	0.96J	1	-
Groundwater Tier I AL		500	500	7,000	7,000	700	200	
Groundwater Tier II AL		5	5	70	70	7	2	

J = Detected below required detection limit
ND = not detected

It was anticipated that this downward trend would continue; however, the cycle repeated itself when the water table rose again in the springs of 2002, 2003, and 2004 (Table 32). In both 2001 and 2003, the water table rose close to ground surface. As the water table rises, contaminants present in the vadose zone are liberated, causing an increase in groundwater contaminant concentrations.

Table 32. Depths to Water by Calendar Year (Well 30900)

Year	Average (Feet)	Minimum (Feet)	Maximum (Feet)
2001	9.4	3.68	14.21
2002	14.4	12.1	15.23
2003	9.0	3.12	15.42
2004	10.33	6.54	14.11

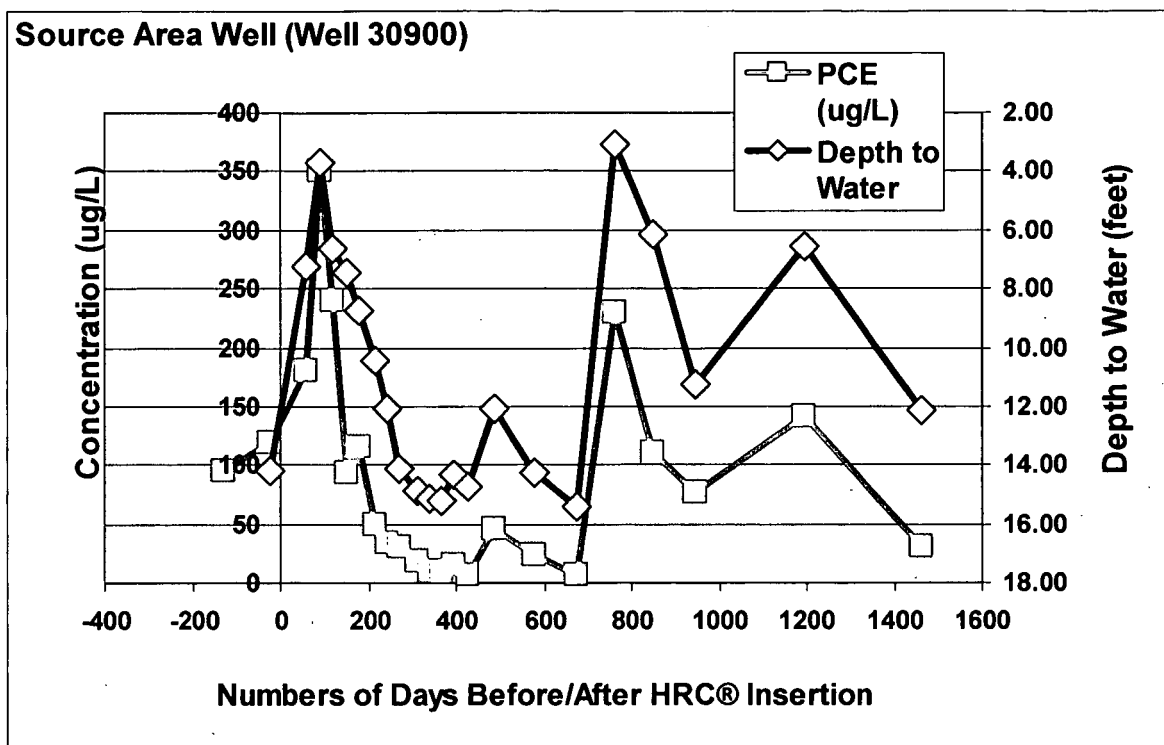
Although the concentration of PCE increased, it did not exceed past high concentrations in the source area. Both TCE and cis-1,2-dichloroethene concentrations did exceed past values. This could be an indication of a more robust microbial population since it appears that more contaminants were liberated from the soil and a greater quantity was degraded. Based on previous years experience, it is anticipated that the cycle will repeat again in 2005, although the effect might not be as pronounced. As indicated on Figure 25, data from the downgradient well (Well 31001) show a similar pattern.

The initial, expected increase in PCE in groundwater and subsequent releases was most likely because of one or a combination of the following conditions:

- HRC® has surfactant properties. Changes in the surface tension of free phase solvents in the soil pores causes more solvent to be released from the pores.
- A change in the relative solubility of the individual VOCs due to the presence of lactic acid in the aqueous phase that would allow more VOCs to go into solution.
- Other changes in liquid and organic phases caused by changes in pH, temperature, oxidation-reduction potential (ORP), etc. caused by addition of lactic acid or by increases in biological activity.
- A seasonal increase because of the rising water table with dissolution and release of additional contaminants from the vadose zone.

As shown on Figure 26, as the water table rises, higher contaminant concentrations are seen in the source area well (Well 30900). HRC® and other possible hydrogen donors like ketones are present in the vadose zone and as the water table rises into the vadose zone, they are released into the groundwater, inducing more biological activity. At the same time, additional contaminants are available because more contaminated soil is now below the water table and available for biological and chemical degradation. The lower concentrations of PCE are probably because less PCE is being released to the aquifer as more PCE in the soil and groundwater degrades.

Figure 26. PCE Concentration and Depth to Water in Source Area Well 30900 versus Time



Figures 27 and 28 show the mole fraction (in percent) in wells 30900 and 31001. The relative amounts of degradation byproducts increase as additional degradation occurs and the zone of anaerobic degradation increases. Eventually these byproducts are also degraded and their mole fraction decreases as it did in the source area in October of 2002. The release of additional PCE in the spring of 2003 and again in 2004 appears to have added additional degradation products and again increasing the ratio of cis-1,2 dichloroethene to the other species, suggesting that the area of biological activity increased again as in 2001.

Figures 24 and 27 also show cis-1,2-dichloroethene occurs at higher concentrations in the source area than downgradient. The accumulation of cis-1,2-dichloroethene at enhanced biodegradation sites is known both here and at other sites. Although there could be others, only one type of bacteria, *Dehalococcoides ethenogenes*, is currently known to anaerobically degrade cis-1,2-dichloroethene (Maymó-Gatell, et al. 1999). Recent research (Kean, 2003) has found that when the concentration of hydrogen donors is high, cis-1,2-dichloroethene degradation is arrested and will accumulate. As previously mentioned, the increase in hydrogen donors is associated with the rise in water table flushing HRC®, ketones, and other hydrogen donors out of the vadose zone. When the concentration of hydrogen donors drops, such as downgradient from the insertion area, *Dehalococcoides ethenogenes* is better able to compete with other bacteria (methanogens) for available resources and cis-1,2-dichloroethene concentrations drop.

Figure 27. Mole Fraction Percent of PCE in Source Area Well 30900 Relative to its Degradation Products Over Time

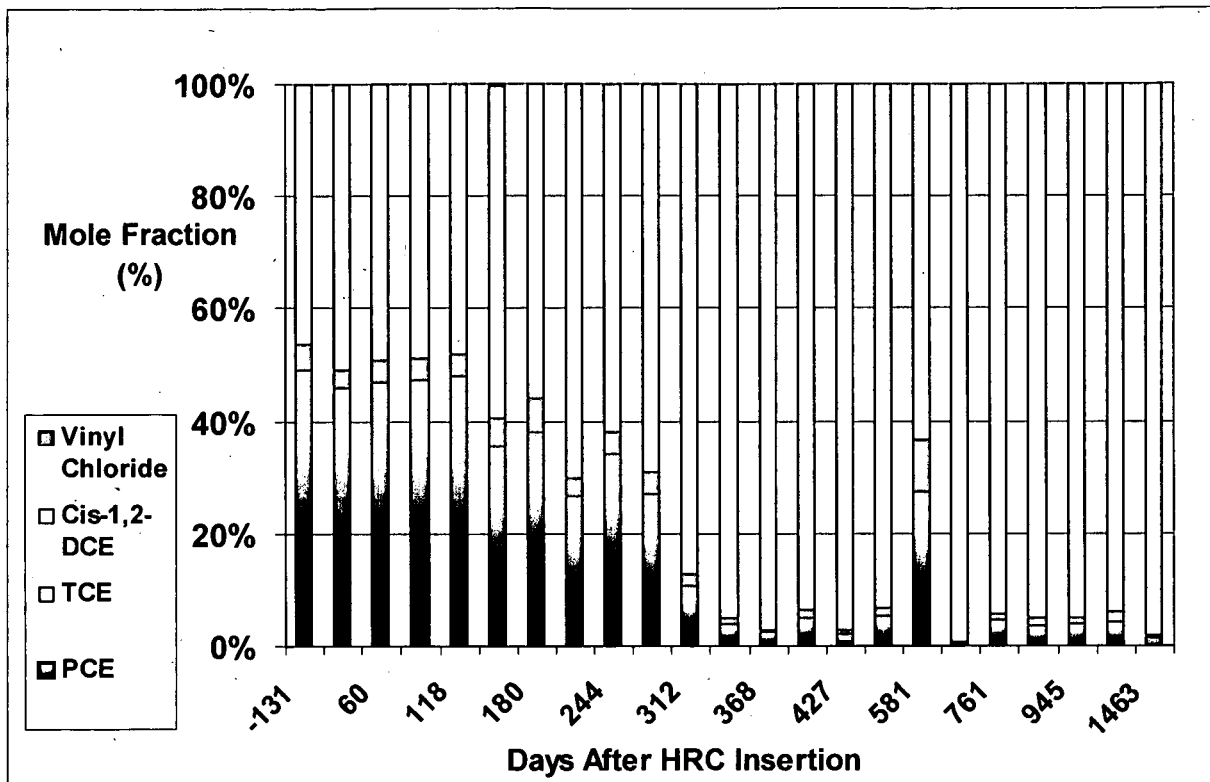
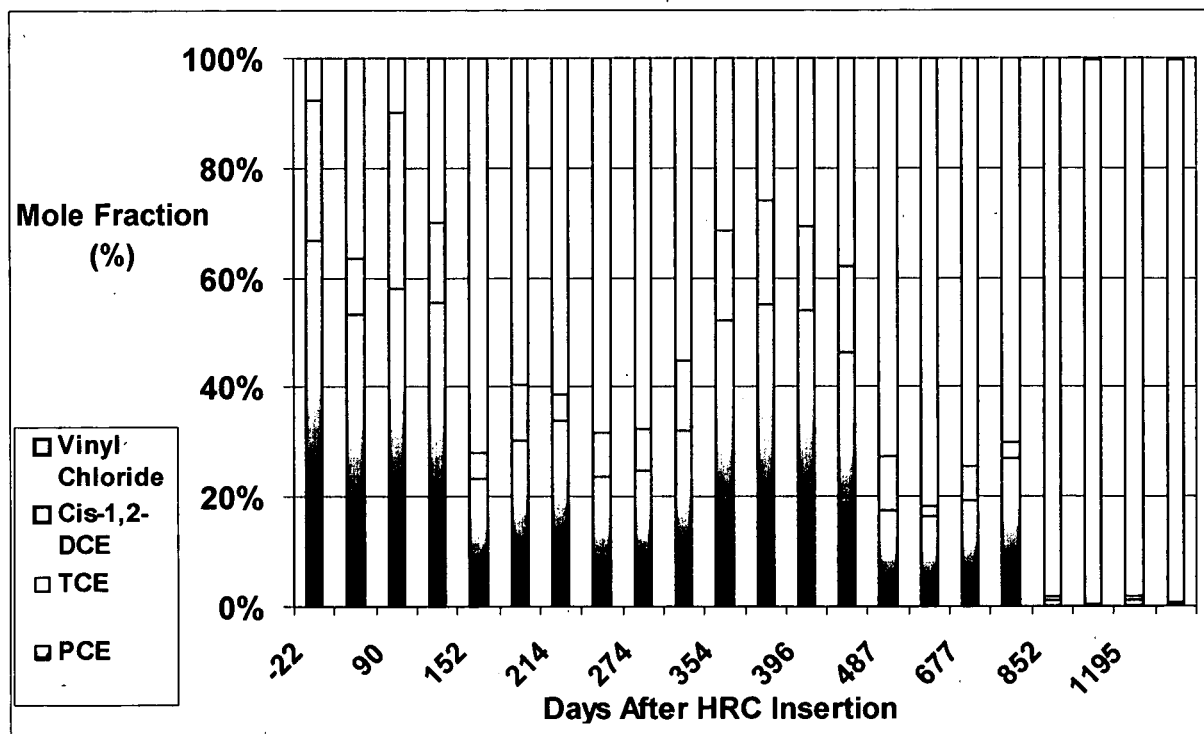


Figure 28. Mole Fraction Percent of PCE in Downgradient Well 31001 Relative to its Degradation Products Over Time



Cis-1,2-dichloroethene degrades to vinyl chloride and then to ethene. As shown in Table 31, vinyl chloride is present at low or nondetectable concentrations. Vinyl chloride degrades rapidly and can degrade by either aerobic or anaerobic biodegradation (Davis and Carpenter 1990) (EPA 2005). Published degradation rate constants have been developed based on EPA funded research at the Dover Air Force Base in Delaware (Clement, et al. 2000). These rate constants (both aerobic and anaerobic) were based on past research, analytical data, and modeling results. The anaerobic first order degradation rate of vinyl chloride is approximately 10 times the anaerobic degradation rate of cis-1,2 -dichloroethene and approximately 25 times the degradation rate of PCE. This means that the concentrations of vinyl chloride are going to be low when it is produced in anaerobic areas because it is not in the environment that long. The rate for ethene removal is even faster. Ethene is detected when the cis-1,2-dichloroethene concentrations are high. Ethene might be more readily detected than vinyl chloride at these times because the analytical method is different and the high cis-1,2-dichloroethene concentrations do not raise its detection limit.

Initial increases in concentrations after HRC® and when the water table rises indicate that VOCs are being transferred from the soil to an aqueous phase, potentially accelerating both soil and water remediation. Typically, the VOCs trapped in the saturated and vadose zones have been the most difficult phase to remediate and continue to act as a contaminant source. Since these are being mobilized and then biologically degraded along with contaminants in the dissolved phase, this is a much more robust treatment methodology than simply biologically degrading the dissolved fraction or Dense Non-Aqueous Phase Liquid (DNAPL) pools below the water table.

As shown in Table 31, the presence of other degradation products such as trans-1,2-dichloroethene, 1,1-dichloroethene, vinyl chloride, and ethene demonstrates that degradation is occurring because these contaminants were not associated with releases at the PU&D Yard. The increase in the ratio of degradation products relative to PCE concentrations also confirms that degradation is occurring. Figures 28 and 29 show this increase in degradation products over time.

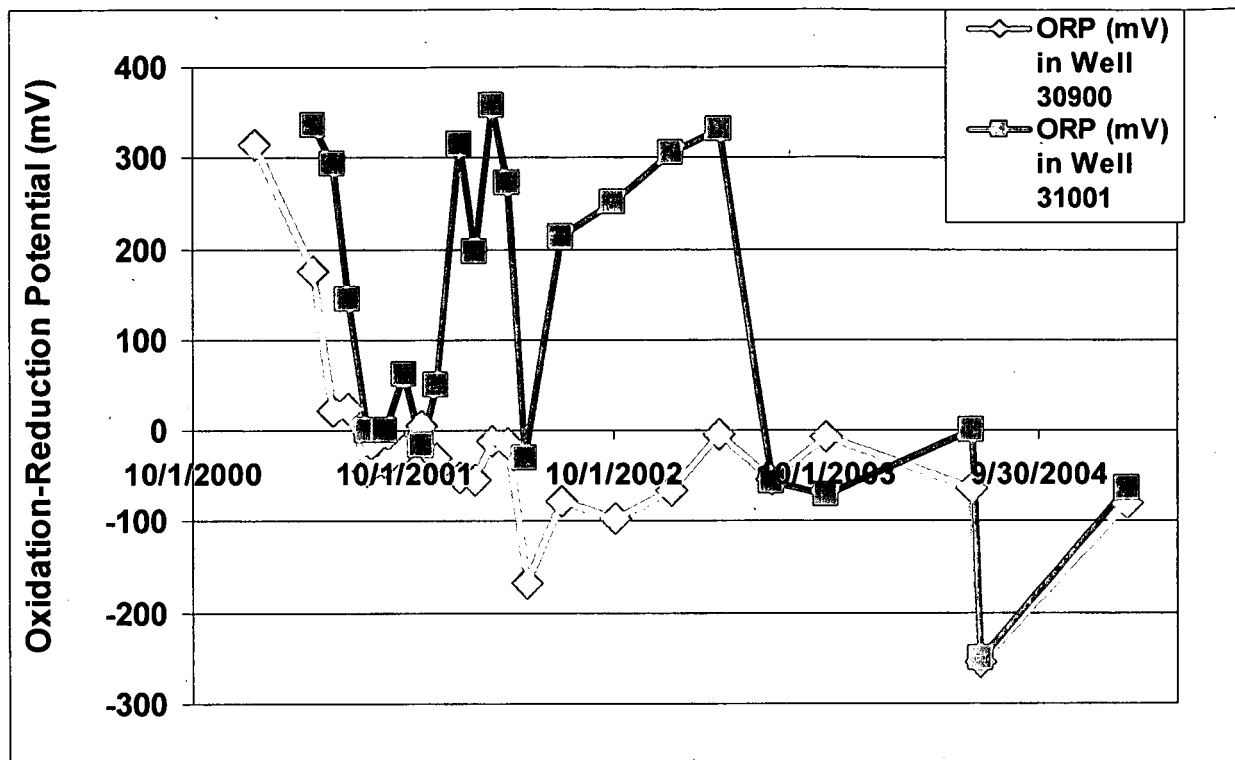
The area of anaerobic degradation appears to expand and contract with water table fluctuations. The area expands as HRC® and other hydrogen donors are released and contracts as it is consumed. Figure 29 shows how ORP changes with time in both the source area well (Well 30900) and in the downgradient well (Well 31001). The measurements were made using a silver/silver chloride electrode with a three-normal potassium chloride filling solution. Reduced conditions in the source area well increased as the anaerobic bacterial community developed. Because it is at the center of the community, it has remained in a reduced state while the downgradient well has responded to the expansion and contraction of the biological community.

Downgradient, the area of reduced conditions increased but then contracted when the HRC® was consumed and the area of anaerobic degradation shrank. When the water table rose, and more HRC® became available, the area of reduced conditions again expanded. Since startup, this cycle appears to be occurring yearly. Figure 29 also shows seasonal variations in the downgradient well. When more HRC® was released in the spring, the area of anaerobic bacteria expanded to include this well and the ORP dropped. This cycle appears to affect cis-1,2-dichloroethene the most.

When the water table rises, the area of reduced conditions and anaerobic activity get larger and more hydrogen donors are present; the concentration of cis-1,2-dichloroethene increases as shown on Figures 25 and 26. Farther out from the anaerobic core where the concentration of

hydrogen donors is lower, cis-1,2 dichloroethene degradation is probably occurring as it does when the core shrinks in the fall and the ORP rises in Well 31001.

Figure 29. ORP in PU&D Yard Wells versus Time

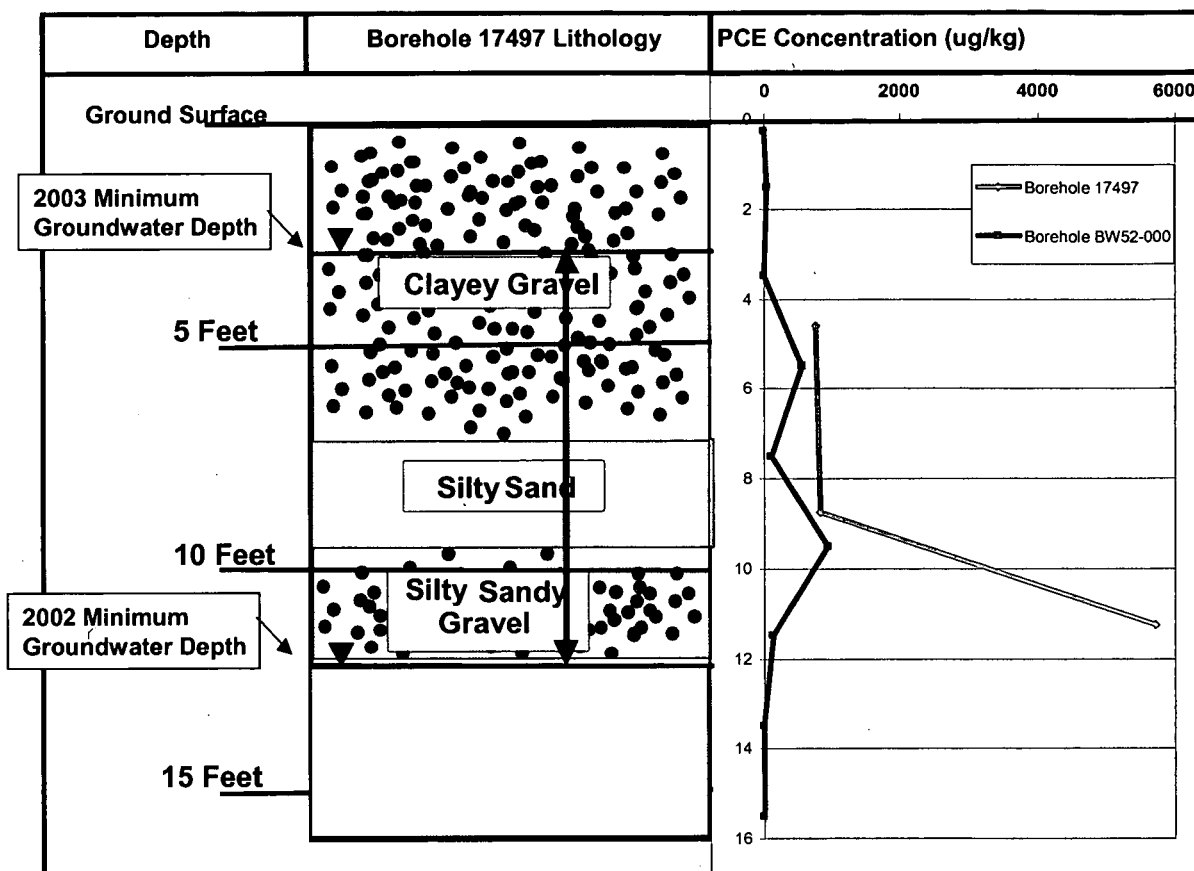


In September 2002, Borehole 17497 was twinned with a new borehole (Borehole BW52-000) to determine whether soil concentrations had been significantly reduced. Soil samples were taken at two-foot intervals from 0.5 feet below the surface down to 15.5 feet below the surface and analyzed for VOCs.

Figure 30 shows the differences in PCE concentration with depth between the original soil sample and the sample after treatment. Prior to HRC® insertion, the highest concentration of PCE was 5,700 micrograms per kilogram (ug/kg) occurring below the water table at a depth of 11.25 feet. The more recent sample from the corresponding borehole interval had a PCE concentration of 140 ug/kg or a 97.5 percent reduction in concentration. As shown on Figure 30, there appears to have been a reduction in PCE both above and below the water table.

Also shown on Figure 30 are the minimum groundwater depths for 2002 and 2003. This illustrates how groundwater levels rise and fall through contaminated vadose zone soils, the likely source of both additional HRC and contaminants. Because this rise in groundwater elevation was coupled with increased degradation, it is assumed that soil concentrations were further reduced.

Figure 30. Lithology and Soil Concentrations of PCE (ug/kg) vs. Depth (feet from surface) in the Source Area



7.3 Conclusions and Work Planned

The continued decrease in PCE and appearance of its byproducts provide direct evidence that the contaminant plume is being degraded. Other than possibly monitoring, no additional work is planned for this site. A treatability study report (K-H 2001c) was completed in October 2001 and provides additional information not contained in this document.

This technology is effective on contaminants in the dissolved phase but also is effective on the organics trapped in the soil that would normally act as a continuous source of contaminants. Pump and treat systems and passive systems such as the Mound Site Plume and East Trenches Plume treatment systems only treat the contamination in the groundwater plume. These systems are expected to operate for many years since the trapped organics will continue to feed these plumes. With enhanced *in situ* biodegradation, organic compounds are liberated from the soil and consumed over a relatively short period. In addition, because of groundwater fluctuations, much of the contaminants in the vadose zone also appear to have been removed and destroyed.

Enhanced *in situ* biodegradation appears to be a viable technology for groundwater remediation at RFETS. It is best suited for areas with organic compounds trapped below the water table although it could be a viable technology above the water table. In areas where there are large quantities of free phase organic compounds, other technologies might be more viable or might be combined with enhanced *in situ* biodegradation. This technology is not as effective in some

areas where groundwater flows into surface water since there is insufficient residence time to fully degrade all of the degradation products prior to reaching surface water. Additional details of its application in other areas of RFETS are described in the Groundwater IM/IRA decision document (DOE 2005a).

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